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MATTERS OF NO MOMENT

By P. E. Cleator

I am, I suppose, the only person who can give a reasonably full and comprehensive account of the Society's early history, and from a stream of messages which have pursued me half-way round the world, I gather that there is some anxiety in London lest I suddenly depart this life, leaving the tale untold. Let me say at once that the burden of knowledge does not weigh unduly upon me, particularly at the time of this writing, which finds me stewing and steaming in the African tropics. My wayward thoughts, alas, will persist in dwelling upon matters far less exalted than the genesis of astronautics in the United Kingdom—iced drinks, revolving fans, air conditioning, cold storage, frost bite, a typical English summer, the North terrestrial Pole. . . .

Fortunately, the story of how the Society came into being has already been embalmed in print on more than one occasion,[1] and there is thus no need to recount it here. Sufficient to state that at a preliminary gathering of three or four interested people at my home, early in October, 1933, it was decided (*a*) that a British Interplanetary Society should be formed; and (*b*) that the first official meeting should be held in Liverpool on Friday, 13th of that month.

This first assembly took place in a suite of offices in Dale Street, and in the course of the general discussion which arose, I urged the need of some form of printed *Journal*. Such a publication, it seemed to me, would serve not only to retain the interest of existing members, but would provide something tangible to send to prospective ones. The need was not disputed, and it was readily agreed that I, with some experience of setting down plain words on plain paper, should be saddled with the task of editing it. The problem of how such a venture was to be financed was solved, temporarily at least, by my offering to pay the cost of the first issue out of my own pocket. At the same time, I announced that a monetary prize of one guinea awaited the member who submitted the best black-and-white cover design—and reserved the right to submit a design myself. Those members who possess, or who have seen, copies of early *Journal* issues, may recall a vision of a streamlined rocket-ship in billowing ascent, with a jumble of skyscrapers and an over-full Moon stationed in the background. This was the winning effort, selected by popular vote from a collection of entries anonymously submitted. As soon as the winning design

(Editorial Note:—*This is the first of two articles on personal reminiscences of the early days of the Society, the period covered by Mr. Cleator's article being October,* 1933, *to February,* 1937. *The second article, by Mr. H. E. Ross, will follow in a subsequent issue of the Journal.*)

had been chosen, the perpetrator of it was called upon to disclose himself. And not a little foolishly, I had to confess that I'd carried off my own prize.

The first and obvious essential was to build up membership, and in the months which followed, strenuous labours to this end were performed on the Society's behalf—most of them by me. There were, of course, dozens of other very necessary duties which were admirably carried out by those who undertook them. But I was the only member who was recklessly prepared to neglect the mundane matter of making a living in an all-out effort to place the Society on its feet, and this gave me an unfair advantage from the start. While others attended to the running of the Society in their spare time, I perspired over the preparation of public lectures, sought out and interviewed various people throughout the British Isles and most of Europe, and wrote lavishly for papers and magazines. On one memorable occasion, I actually contrived to persuade a highly dubious editor to serve his unsuspecting customers with a weekly news feature on matters interplanetary—an unheard-of innovation in those dark and distant days. I even sold a cinema manager the idea of giving a special showing of UFA's *Frau Im Mond*—and then made the discovery that a copy of the film was nowhere to be had! One result of all this activity was a daily postbag of alarming proportions, and attending to it cost me many a night's sleep. And as if all this were not enough, I began the writing of a book on the subject. . . .

We were, of course, anxious to associate ourselves with like-minded groups, and to this end, early in January, 1934, I flew to Berlin to make personal contact with rocket experimenters there. By this time, however, the famed *Verein für Raumschiffahrt* was no more. A certain Rudolf Nebel, it appeared, had, of his own sweet accord, turned it over to the Nazis, and leading members such as Willy Ley, whom I saw first, had resigned in protest and disgust. I subsequently met Nebel, and found him polite but uncommunicative, as befitted a knight of the New Order. So I returned to Ley, and we dined pleasantly together, and discussed plans for the future. How were we to know that a year later he would be a refugee on my doorstep?

Ley not only joined the Society, but he furnished introductions to Dr. Otto Steinitz, and to such personalities abroad as Esnault-Pelterie in France, Ing. Guido von Pirquet in Austria, G. Edward Pendray in the U.S.A., and Dr. Jakow Perlmann and Professor Nicholas Rynin in the U.S.S.R.—all of whom became members. It was through Ley, too, that we approached Professor A. M. Low, whose response was immediate, and who most generously assisted the Society in many different ways.

Soon after my return from Europe, I received a telegram from H. Grindell Matthews, intimating that he wished to join the Society, and inviting me down to London to see him. It transpired that he was busy with a scheme for a massed rocket barrage for use against fleets of hostile bombers, and had provided himself with an extensive mountain-top research station on Tor Cloud, in the vicinity of Swansea. When I later visted the place, I found it surrounded by a high fence (electrified, if I remember aright!), and replete with concrete observation trenches and private air field. Matthews was convinced of two things—that a world war was on the way, and that rockets would play no small part in it. He wanted me to take up residence at Tor Cloud, and work there with him. It

was a tempting offer, which I declined on the grounds that I was not interested in the rocket as a weapon of war. Neither, it seemed, was the War Office—Matthews complained of having encountered one frustration after another there. And as things turned out, he died (in September, 1941) without seeing his scheme put into practice. That it was ultimately used is evidenced by the anti-aircraft batteries of so-called "Z" guns, which made a somewhat tardy appearance a year or so after his death. So far as I am aware, Matthew's pioneer efforts in this connection have received no official recognition, or acknowledgment, or even mention.

It was also in 1934 that the American Interplanetary Society deemed it expedient to change its name to the American Rocket Society. The original name, it appeared, was something of an affront to the susceptibilities of the sober minded. There was at least one advocate of similar action on the part of the British Society—J. G. Strong, a London member, whose name, happily enough, is still to be found in the current *Annual List of Members*. He argued eloquently and at length for a title such as the Institute of Rocket Engineers, or the Society of Rocket Engineers, and much of this eloquence was poured down my ear on the occasion of a meeting between us in the City. In the end, I asked him to set down his arguments for publication and ventilation in the *Journal*. At the same time, I promised to make out a case for the opposition, and invite the opinion of members. The two sets of arguments duly appeared,[2] and, offhand, I cannot recollect that so much as a single letter was received which favoured the proposed change. At all events, it was not made.

Towards the end of 1934, advance news of Willy Ley's impending departure from the Reich reached me by way of a letter smuggled into Holland, and there posted. It was a time of deep depression in These Isles, and in a guarded reply, I advocated the U.S.A. as a more inviting haven of refuge—and at once communicated with Pendray of the American Rocket Society, who responded magnificently to the occasion. Thereafter, I journeyed to Dusseldorf, to meet Ley on his way out. But the plan miscarried, and after days of fruitless waiting, I had to return without him. Luckily, he was successful, early in the New Year, in making his way to England, where he stayed as my guest. Needless to say, he was a star attraction at a number of Society meetings, and before me as I write is a reminder of one such gathering, in the shape of a newspaper photograph. The picture purports to show Ley examining his plans for reaching the Moon, closely surrounded by nine members of the Society, all intently peering at—a blank sheet of paper!

This particular journalistic felony was compounded in the upstairs room of a café in Liverpool's Whitechapel, an unpretentious place, which exactly suited our needs: it was centrally located; it remained open until late hours; it provided light refreshments as and when required; and its charges were absurdly cheap. At this meeting place, some weeks after Ley's departure, an incident occurred which might easily have altered the entire course of the Society's history. On the evening in question, we were all gathered as usual in our upper room, deeply engrossed in some discussion or other, the substance of which now eludes me. As the discussion grew more and more involved, some of us became conscious, in a vague and disinterested sort of way, that a most infernal din was going on

in the near vicinity, a din made up of shouting, banging, and the clanging of bells. The discussion, nevertheless, went serenely on—until it was rudely interrupted by a member of the Liverpool Fire Brigade, who crashed open the door, and stood framed in the entrance, begrimed, soaked, axe in hand, and unable to credit the evidence of his smoke-filled eyes. Below, the premises were completely gutted, and the entire company of us, with our one way of escape cut off, had very nearly been roasted alive !

The publication, early in 1936, of my *Rockets Through Space* contrived to bring the interplanetary idea before a much wider public (it even led to an invitation by the B.B.C. to give a brief discourse on the subject) and membership of the Society benefited accordingly. By a coincidence, the book appeared about the same time as the general release of the film version of H. G. Wells's *The Shape of Things to Come*. One of these Things, it may be remembered, was the start of a journey into space. Unfortunately for us exponents of space travel, Wells inexplicably chose completely to ignore the rocket, resurrecting instead that impracticability of impracticabilities, the Jules Verne cannon, which nonsense was solemnly retailed to the public as a profundity of the future ! But yet more shocks were on the way. As early as 1934 we had been informed by the Under Secretary of State that scientific investigation had shown that jet propulsion had no future. And now, in March, 1936, we made the discovery that rocket research was officially forbidden under some Explosives Act or other of 1875—which idiotic ban I denounced roundly at the time,[3] and the consequences of which I have had occasion to refer to since.[4]

Among the many new members who joined the Society in 1936 were the Count and Countess von Zeppelin, whose place of residence in this country was at Blackwater, Hants. I kept up a correspondence with them right up to the outbreak of war, whereafter there was complete silence. It seems, however, that they made good their escape to the Fatherland, for idly tuning in to a German propaganda talk one day, I was startled to hear a member of the British Interplanetary Society discoursing on the stupidity of conflict between the British and German peoples. It was the most charming Countess, doing her bit. . . .

This brief account must end, alas, on a somewhat discordant note. At a meeting of the Council held in April, 1936, it was conveyed to me, in no uncertain terms, that it was considered I was playing too large a part in the affairs of the Society. Too many people, it seemed, were writing to me instead of to the Secretary, to the detriment of all concerned. I was certainly in no position to refute the charge, for I had devoted more time, money, and effort to the Society than all the complainants put together. Nor, in the face of it, could there be any question of my remaining on the Council. And as I tendered my resignation from that body and relinquished the editorship of the *Journal*, and gave assurances that all correspondence relating to the Society which happened to come my way would be forwarded to the Secretary, I wondered if the malcontents had any idea of what they were taking on. Apparently, they hadn't, for they produced two belated issues of the *Journal*—and then blew up! In a plaintive editorial in the second of these issues, dated February, 1937, it was actually announced, publicly and in print, that the work was too much for them! This

sorry admisssion did much to explain the calling of an emergency meeting in the previous December, at which I had been astounded to hear it proposed that the management of the Society should be handed over to a newly-formed London branch—a proposal which had been accepted by the meeting, and with it my resignation as President.

It seemed to me, in those strenuous and uncertain days, that the proposed new management, about which little or nothing was known, might well prove as incompetent as the old, and that the Society's very existence was being endangered. Looking around me to-day, I begin to entertain the suspicion that perhaps my fears and apprehensions were a little on the pessimistic side. . . .

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THE RESEARCH SCENE—4

By K. W. Gatland

Zeus

A new high-altitude rocket known as the *Zeus* is under development at the Naval Ordnance Laboratory, White Oaks, Ind. No other particulars are available of this project, except that the Sperry Gyroscope Company are to provide the control equipment. An aircraft firm, probably the Glenn L. Martin Company, will build the hull and carry out the final assembly.

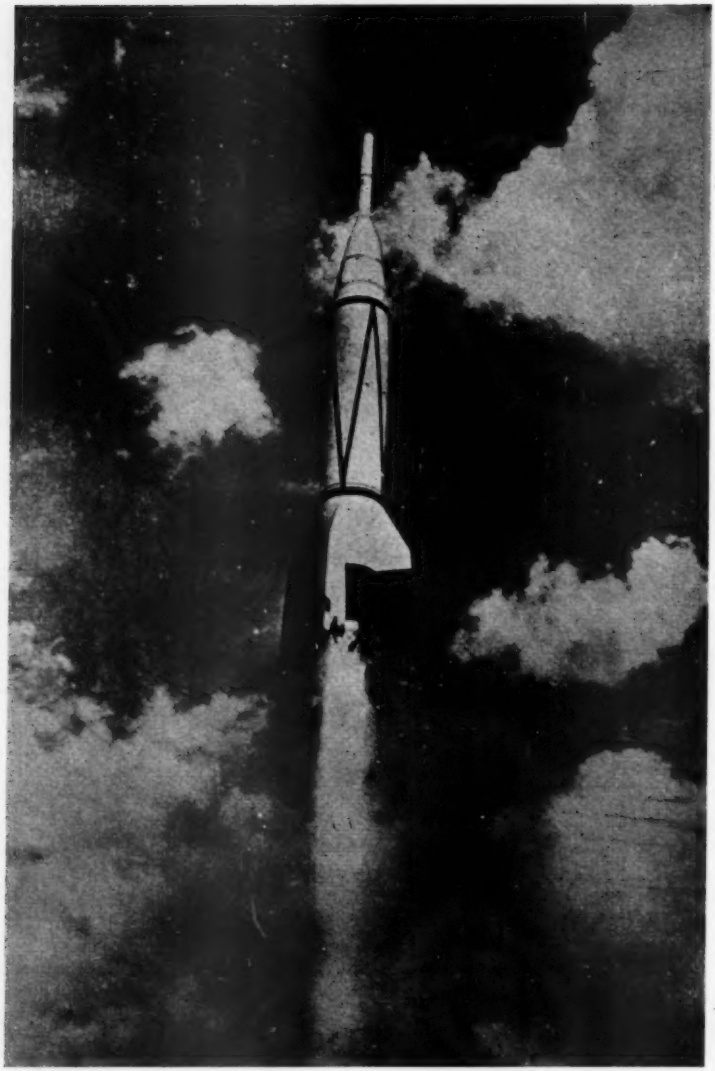
Set-backs to "Viking" Programme

The U.S. Navy's *Viking* rocket, still undergoing preliminary tests at the White Sands Proving Ground, New Mexico, is expected to reach a peak altitude of 200 miles. The programme has suffered setbacks, however, because of an unexplained cut-off of the motor before the rockets reach the "all-burnt" condition. The defect occurred in the case of the second missile (on September 6) at 16·9 km. (10·5 miles), which gave a maximum altitude of only 53·3 km. (33 miles).

An unsuccessful attempt to launch *Viking* No. 2 took place on August 25, when the missile refused to lift from its platform; this was attributed to a leak in an oxygen feed line which apparently froze the starting valves.

Last of the A.4 Rockets

The United States high-altitude programe using *A.4's* is scheduled to end this spring. According to a spokesman at the White Sands proving ground, supplies of the veteran rocket are now almost exhausted, and the gap will be filled by *Aerobee* and *Viking* types, for which there have recently been increased orders.



WAC Corporal and V.2 Booster Rocket.

The Two-Stage Experimental Rocket fired at White Sands, New Mexico, U.S.A., on February 24, 1949. A rebuilt German V.2 was fired with a smaller "WAC Corporal" Rocket in its nose. At an altitude of approximately 20 miles the rockets separated and the smaller one continued to the peak of the flight. The small pencil-like object on the nose of the rocket is the "WAC Corporal," which reached a record altitude of 250 miles.

The *A*.4 has, of course, been the nucleus of all high-altitude research since the war and, despite the mode of its introduction to Britain in 1944, its passing will be viewed with regret.

The story of how the Americans built up their *A*.4 research programme has already been told and it is in many ways unfortunate that British research was not allowed to develop along similar lines.

To judge from the film, "Operation Backfire," considerable stores of *A*.4 equipment fell into our hands after the surrender and much useful work was undertaken by the Army at Cuxhaven, using German personal, to re-build the rockets and to provide complete servicing and launching facilities. In fact, what might have been the basis of a firm research foundation was built up within the space of a few months, but apart from a critical report on the accuracy of long-range rockets (which in the tests had been aimed at targets in the sea) and an excellent 40-minute film, it appears that these were the only material result. The possibility of using the *A*.4 as an instrument of research was apparently not recognised, and nearly five years' later we have yet to see a British programme of "scientific rocketry."

Project Rand

Although the *A*.4, under American direction, has every right to be termed "the embryonic spaceship," one of its most important roles has been that of "booster." At White Sands last February, a signal advance in rocket technique occurred when a *WAC Corporal* rocket, released from an *A*.4 at "all-burnt," climbed to an altitude of 402·3 km. (250 miles).

This first demonstration of a high-altitude step-rocket marks an interesting new phase in rocket development which within a few years may lead to the establishment of a small close-orbit vehicle. It is significant that Wernher von Braun, chief scientist in the German *A*.4 programme, is engaged in the RAND project (sponsoring the Earth Satellite Vehicle Programme) in which sections of the U.S. Armed Forces and certain research foundations and aircraft firms are participating.

Guided-Missile Research in U.S. Aircraft Industry

There are few major aircraft firms in the United States which are not expanding their research and production facilities to include work on guided-missiles. The Douglas Aircraft Company, collaborating in the RAND project, are carrying out basic investigation for the Earth Satellite Vehicle Programme and, on the production side, are busy with the *Aerobee* contracts. The particular concern of Glenn L. Martin is, of course, the *Viking*, while firms such as Boeing and Ryan are producing ground-to-air and air-to-air rocket weapons.

A large expansion is currently taking place at the factory of North American Aviation, Inc., at Downey, California, where specialised problems encountered in guided-missile construction and operation are to be investigated. The rocket research laboratory is within the main factory building and is intended for studies of high-altitude operation—extremes of temperature, humidity, etc., *g*-loads, vibration and gyro-mechanisms. To simulate the condition of a missile in flight, a test chamber having a temperature range

of from — 60° C. to + 80° C. will be incorporated. It will be possible to produce atmospheric pressures equivalent to operation up to an altitude of 30,480 metres (100,000 feet). A centrifuge as well as horizontal and vertical vibration machines will be installed.

After two year's work on its construction, the firm's proving ground in an isolated canyon of the Santa Susanna mountains, near Los Angeles, is now in operation. The present testing localities are for rocket units of from 136 to 1,360 kg. (300 to 3,000 lb.) static thrust.

General Electric Telemetering System

A compact telemetering device for research rockets, capable of 28-channel transmission 35 times per second, has been developed by the General Electric Company's electronics laboratory at Syracuse, N.Y. The unit, which weighs only 12·7 kg. (28 lb.), records temperature, pressure, acceleration, vibrations, stresses, etc., and telemeters these data to the ground, where they are interpreted on cathode-ray tubes and the images recorded on motion film.

Another contribution by General Electric is "bouncing putty," a viscous and highly resilient silicon material previously used as a core for golf balls. The idea is that certain delicate equipment is buried in the material and shocks thereby distributed evenly over the entire surface of the instruments. To test its effectiveness, an automatic motion camera, suspended in the resilient "putty" itself surrounded by an armoured casing, was placed in the tail-fin of an *A*.4 rocket. This simple expedient enabled the camera to survive a 4,830 km./hr. (3,000 m.p.h.) impact with the ground.

Activity at Woomera

After two-and-a-half years of constructional work, the long-range weapons proving ground at Woomera in South Australia, is now in operation.

There is a report that research at Woomera will shortly be expanded to include experiments with bombs, explosives, air-fighting and radar anti-submarine devices.

A new firm known as the Fairey-Clyde Aviation Company (a combination of Fairey Aviation Co., Ltd., and the Clyde Engineering Co.), devoted exclusively to work on long-range weapons under contract with the Ministry of Supply, has been registered in Adelaide. The research centre will be established at Salisbury, 19·3 km. (12 miles) from Adelaide.

Soviet Pyrotechnics

A spate of "unconfirmed reports" of rocket experimentation in the Soviet zone of Germany has lately pierced the "curtain." It is said, for example, that one of the rockets being produced by the Russians—in Germany—"has a range and accuracy sufficient to hit an objective 8,046 km. (5,000 miles) distant"; the warhead allegedly blossoms into 8 or 10 aerial bombs over the target, desolating an area of 8 sq. km. (3·1 sq. miles).

Another report reaching Western Berlin states that the German rocket experimental establishment at Peenemünde (in the Soviet Zone) is at present producing *Feurlillie* rockets. Mention is also made of rocket manufacturing activity at Rechlin, the former experimental station of the German Air Force.

PROF. DR. WERNHER VON BRAUN

History will record that after the great pioneers laid the theoretical basis of the science of astronautics, there came a period (just prior to the recent war) when the first experimental steps were taken by small amateur groups, and then—during the war itself—one man was chiefly responsible for a sweeping advance which at once moved the whole subject into the realms of practical engineering. That advance was the A.4 (or V.2) rocket, and the man was Wernher von Braun.

He was born, a member of the Prussian aristocracy, on March 23, 1912; his father was Minister of Agriculture in von Papen's last pre-Hitler German Government. The young Baron von Braun was a talented and cultured man, speaking five languages and being a keen pianist. His main interests, however, ran along somewhat unconventional lines; he was an enthusiastic believer in rockets and space-travel.

After leaving school in 1930, he worked for a time in the Borsig A.G. locomotive and turbine factory in Berlin, to gain practical experience. Following this period, he pursued academic studies at the Technical High Schools of Berlin and Zurich, gaining his first degree in mechanical engineering in 1932. In the same year, he was granted a pilot's licence for gliders and sailplanes, and the year after, one for powered light aircraft also; later (in 1936) he was to gain a licence for medium-heavy aircraft and aerobatic flying.

Meanwhile, he continued his academic studies and in 1934 the University of Berlin conferred on him the degree of Ph.D. in physics, for a thesis entitled: "Theoretical and experimental contributions to the problem of the liquid-propellant rocket." In 1943, he was appointed a Research Professor—the usage of the term "Professor" being somewhat different in Germany from here, and indicating an academic distinction, not necessarily the holding of a teaching post.

Willy Ley has told us (in a letter printed in the *B.I.S. Journal* of June, 1947) how von Braun came as a boy to the V.f.R., and rapidly proved to be one of their most enthusiastic and hard-working members, taking part in the amateur experiments at the Rakentenflugplatz. In 1932, he was elected to the Board of Directors of the Society, in the face of some opposition on the grounds of his youth. Little did the objectors realise what he was to accomplish before he was many years older!

Soon after this, the German Army put von Braun to work on the development of liquid-propellant rockets for military purposes. By 1937, he tells us, the Kummersdorf Proving Grounds near Berlin had six test stands and a staff of about 80 workers, but even in 1935 an initial 11,000,000 *RM*. (nearly a million pounds) had been voted to set up the much larger establishment at Peenemünde.

The period 1933-1941 saw the development, first at Kummersdorf and then at Peenemünde, of the early small experimental rockets A.1, A.2, A.3, and A.5, of rocket motors for the Ju. 50, He. 112, and He. 176 aircraft, and jettisonable assisted take-off units, of the B.2-B.8 types, for heavy bombers. All these burnt alcohol and liquid oxygen as propellants. Meanwhile, project work proceeded on the A.4, which was first successfully fired in 1942; up to that time, the

German High Command, and Hitler himself, had viewed the Peenemünde programme with scepticism, but thereafter their attitude changed to one of equally extreme enthusiasm, often combined with extravagant demands for mass production and operational use, ahead of the extent justified by the stage of engineering development so far attained.

The executive military head of the Peenemünde establishment was General Dornberger, who was largely responsible for gaining official support for its work, and was also an enthusiast for space travel. However, Prof. Dr. Wernher von Braun had full technical responsibility for all design and development work, and liaison with the many industrial and university organisations associated with the programme. After the *A.4*, this included the "Wasserfall" nitric-acid/amine anti-aircraft rocket, and design studies on the A.9-A.10 trans-Atlantic project. One successful vertical flight of the A.9 top-step, by itself, was made in 1945; the A.9, of course, was a winged version of the A.4. At the peak of its activity, just before the defeat of Germany brought its work to a close, some 4,450 men and women were employed at Peenemünde, including about 900 graduate scientists and engineers.

The nature of the application of his work was certainly not of von Braun's own choosing; he shared the feelings of all men, such as aeronautical engineers and nuclear physicists of all nations, at the prostitution of science demanded by our present immature society. In recent correspondence with the B.I.S. regarding our invitation to him to become an Honorary Fellow, he wrote: "Is it not a pity and a shame that people with the same 'star-inspired' ideals had to stand on two opposite sides of the fence? Well, let's hope that this was the last holocaust, and that henceforth rockets will be used for their ultimate destiny only—space-flight!" Intelligence reports of the interrogation of von Braun after the defeat of Germany, together with the nature of many of the longer-term projects studied on paper by his staff, leave no room for doubt that it was interplanetary travel and high-altitude research rockets which really interested him.

Since 1945, Prof. Dr. Wernher von Braun has been employed by the American rocket research authorities at Fort Bliss, Texas, the base which has supervised the vertical firings of modified A.4 rockets for ionospheric research, from White Sands. In 1947, he was permitted to return to Germany to marry his second cousin, Maria von Quistorp, returning to the States with her and his parents also; he now has one young daughter, born in America and therefore a citizen of that country, as her father also will soon be.

DR. EUGEN SÄNGER

Dr. Sänger is so well-known for his basic theoretical and experimental work on rocket and ramjet propulsion—to both of which subjects he has made outstanding contributions—that it has sometimes been assumed that his main interest lay in the field of aeronautics rather than astronautics. This, however, is not the case and in a recent letter to our Chairman he wrote:—

"If the great majority of human beings or the great organisers of human

Professor Dr. Wernher von Braun.
Elected Honorary Fellow of the B.I.S. in 1949.

society were thoroughly convinced and enthusiastic about astronautics, then scientists and engineers could direct their research work immediately to the centre of space-flight problems. Unfortunately, it is not so. Therefore, I considered the astronautical scientist's task to turn slowly the human mentality towards our target by steps of *fait accompli*. . . . Men are seldom convinced by good reasons, and more often by good facts. . . . Also, I worked always in immediate Government service and had to find a middle course between what I loved and what was demanded." Dr. Sänger went on to say that from now on he hoped to be able to devote more direct attention to the immediate problems of interplanetary flight.

Born on September 22, 1905, at Pressnitz (now in Czechoslovakia), Dr. Sänger received his early education in Hungary and Austria, and then studied at the Technische Hochschule at Graz and Vienna, doing practical work on high-voltage long-distance transmission and on aeronautics—the latter with the Junkers firm at Dessau. He obtained his doctorate in 1931 by a thesis on "Statics of Multiple Spar Wings."

From 1929 to 1935, as a scientific assistant of the Technische Hochschule at Vienna, he published many papers on high-speed aerodynamics, rockets, gas dynamics, etc., and his important book *Raketenflugtechnik* was published in 1933 by R. Oldenbourg, of Munich. From 1936 onwards, Dr. Sänger was the first director of a lavishly equipped rocket research establishment set up by the German Government at Trauen (Hanover). With Dr. Irene Bredt and other collaborators he prepared numerous reports on the construction of rocket motors (some of very large size) working at 100 atmospheres, high-pressure centrifugal pumps for liquid oxygen, light-metal/diesel-oil dispersions as rocket propellants, liquid oxygen-ozone solutions as oxidisers, supersonic catapults and gliders, dissociation in rocket motors, hypersonic aerodynamics and gas-kinetics, rocket propulsion for long-distance military aircraft, and the establishment of the space-station. Much of this work was incorporated in a secret report "Uber einen Raketenantrieb für Fernbomber" (Deutsche Lufo UM 3538, 1944, 376 pp.). This report (according to a recent and apparently well-informed series of articles by the Russian refugee, Tokajev, in the London *Sunday Express*) made a considerable impression on Marshal Stalin, and therefore, presumably, on the Russian aeronautical world. It discussed the design of a rocket bomber of world-wide range, using a very radical flight technique. The take-off, from a supersonic launching carriage, was to be followed by a vertical climb to beyond the atmosphere. Thereafter, the craft was to re-enter the atmosphere and travel along an undulating trajectory consisting of successive high-speed glides and climbs, with gradually diminishing air-speed.

This programme was interrupted in 1942 by the war situation, and Dr. Sänger's further work was mainly concentrated on ramjets for aircraft, fighters and missiles, in association with the D.F.S. organisation at Ainring.

Since 1946, Dr. Sänger and his colleagues have been working in France for the Air Ministry research department on the basic research and development of liquid-propellant rockets, ramjets, pulsejets and their combinations and on a new edition of his book *Raketenflugtechnik*.

Dr. Eugen Sänger.
Elected Honorary Fellow of the B.I.S in 1949.

THE POSSIBILITY OF POTENTIALLY PATHOGENIC ORGANISMS OCCURRING ON ANOTHER PLANET

By E. R. Nye

It is common knowledge that here on Earth there are thousands of species of organisms, one might call them micro-flora, which are grouped under the common heading of *bacteria*. Most of these species are innocuous, but nevertheless, a number are pathogenic, i.e. capable of producing a disease.

It has been found that, in addition to well established types of pathogenic organisms (i.e. in human beings), such as *Mycobacterium tuberculosis*, *Corynebacterium dipheriae*, etc., there exist others which may give rise to disease only on certain occasions; at other times they may normally live as commensals in their human hosts, or perhaps cause disease in lower animals. Of this latter kind, for instance, is *Leptospira canicola*, which causes "yellows" in dogs, or the bovine strain of *M. tuberculosis* which affects man and cattle.

The list may be multiplied, but it is sufficient to show that these micro-organisms are adaptable. In addition, it might be mentioned that nearly all of the pathogenic bacteria are grown, for bacteriological purposes, on artificial culture media—further evidence of their adaptability. A great range of variation may also be found, e.g. under certain conditions a strain of organisms may become non-virulent, but if the conditions are again altered, its virulence may be restored.

This is connected with the fact that most bacteria multiply very rapidly under favourable conditions—one bacterium giving rise to thousands overnight. Thus, the occasional mutation which takes place in a member of the higher animals over a course of thousands of years may take place in the bacteria to give a new strain or variant in the course of one week.

This now leads us to the fact that when the first interplanetary traveller leaves his ship and steps on the soil of another planet, he must have in mind the possibility that it is already populated with simple, but highly adaptable, micro-organisms, which may find in him a new and highly congenial environment.

Before examining briefly some of the steps which could be taken to avoid infection by some of these hypothetical organisms, it should not be overlooked that human beings are not infrequently invaded by members of the Protozoa, Nematoda, Helminths, and other animals higher up on the evolutionary scale than the bacteria.

What precautions might we then take to avoid infection? A little reflection will make it apparent that any precautions taken will necessarily be conditioned by the world which it is contemplated visiting. On the Moon, for instance, bacteria, if present, will probably be highly adaptable to changes in temperature, perhaps spore-forming, vegetative reproduction possibly taking place within an exceedingly short period of favourable temperature when lunar night changes into day, or vice versa. On Mars, however, one might expect to find flora inured to extremes of cold, but not of heat, and the thermal death point of Martian bacteria may well be below that of human body temperature, in which case they will give little cause for concern, as the space travellers will act as their own sterilizers. On Venus, one might easily expect to find

bacteria growing strictly anaerobically, as there appears to be no oxygen in the planet's atmosphere.[1] It may well be, however, that 98·4° C. is too low a temperature for active proliferation, and so again give no cause for concern to interplanetary travellers.

It now remains to consider how we might prepare ourselves against possible infection from the bacteria which one might expect to find.

A first consideration is that progress from a spaceship on to another planet would probably be impossible without the use of a space-suit, and infection whilst outside is therefore unlikely. The danger would lie when the explorers returned and re-entered the ship, thus introducing organisms inside from their contaminated suits. This danger might be obviated by having a lock in which the suits could be discarded before entering the "living quarters" of the vessel. If this lock was then opened to the vacuum, cold, etc., of outer space during the return journey, it is very likely that any organisms present would be killed, though it might be considered desirable to bring planetary bacteria back to the Earth for further investigation, in which case special care would need to be taken to preserve their viability.

An obvious point arising is the question of whether it is possible to determine the presence of bacteria before actually leaving the ships. This is something which could be done, of course, but it would necessitate the carrying of special equipment and the ability to secure samples of the soil or vegetation while inside the ship, and determine any effects upon guinea-pigs or mice. The special equipment needed would include quantities of various culture media (for it seems likely that organisms capable of growing in ordinary bacteriological media might find growth possible in humans), experimental animals, and sterile sampling apparatus, the whole equipment hardly exceeding two or three kilos in weight.

There are probably many reasons which might be advanced against taking proper precautions, but it should always be borne in mind that it is simply futile to equip an otherwise perfect expedition, only to have it destroyed or incapacitated by some new and unknown infection.[2]

REFERENCES

(1) S. M. Mather, *Journal of the B.I.S.*, Vol. 6, p. 194.
(2) H. G. Wells, *The War of the Worlds.*

Definitions Used in the Text.

Commensals.—Organisms living within the body, but not producing disease. Usually confined to the alimentary tract and naso-pharynx, although sometimes found elsewhere.

Culture Media.—Any artificial medium used for the growing of bacteria and moulds in the laboratory. In the simplest form a meat-extract broth.

Helminths.—A general term referring to intestinal worms.

Nematodes.—Round worms, e.g. Ascaris.

Spore-forming.—The capacity of some bacteria, notably the Clostridia, to form a very resistant spore stage in which state they may survive extremes of temperature and desiccation.

Virulent.—A term used to distinguish between the disease-producing and innocuous strains of a particular organism.

HISTORY OF ROCKET DEVELOPMENT

A review of the film shown to Fellows of the British Interplanetary Society at the War Office, Whitehall, on July 16, 1949.

Not to be confused with *Rocket Flight** produced by the R.A.F. Film Unit (which nevertheless incorporated many sequences from it), this film, which is silent and runs for approximately 1½ hours, was made during the war in Germany. As originally planned, there was to be a series of three films covering: (*a*) pre-war research; (*b*) wartime development, and (*c*) future prospects; but apparently parts two and three never materialized.

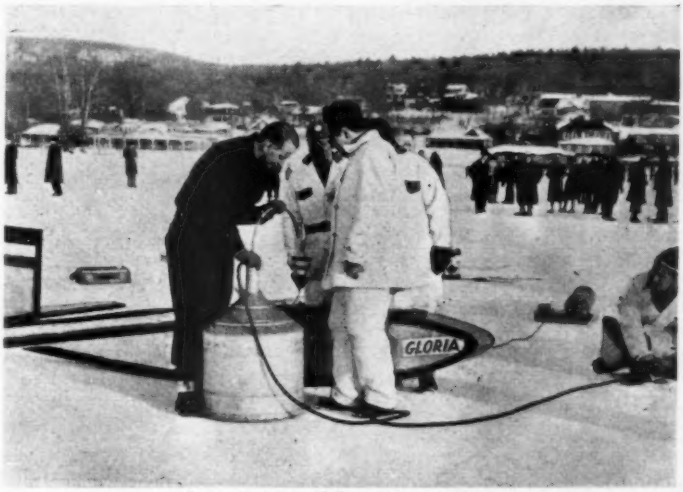
Though admittedly a scrappily produced documentary, part one is nevertheless a most valuable record, for it contains evidence of research—notably by Tiling and Sänger—which, to the knowledge of this writer, has not previously been available in this country.

Apart from the more sensational aspects of pre-war rocket experimentation as portrayed by Opel and Zucker and the eminently successful Tiling powder rockets, the film is largely a chronicle of failure amongst the pioneers of the bi-fuel rocket. On reflection, perhaps *failure* is a harsh term for these earnest workers since, apart from experiments which were more in the nature of stunts, profit was invariably made of error in subsequent work. Experience, it is said, is a hard school, and it should be remembered that the often crude and seemingly inconsistent research of private individuals and small groups of enthusiasts in the early "thirties" provided the ready foundation for the development of the A.4 long-range rocket, the rocket interceptor, the guided-missile, and, specil fically, the high-altitude sounding rocket which—a mere 20 years after—is on the verge of flight into space. That more accidents did not occur in those early days is surprising for, judging from these records, it was not unusual for an experimenter to peer closely upon a harnessed jet without observing the most elementary precautions.

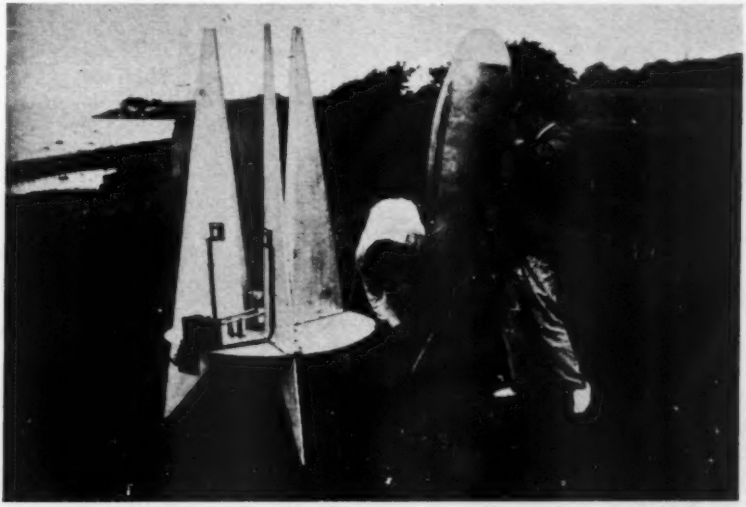
We will gloss over the opening scenes, which commence with a parallel, a resumé of aircraft development. Interest begins with a sequence of photographs of well-known personalities connected with the rocket idea, together with examples of their publications: Ganswindt, Ziolkovsky, Oberth, Goddard, Valier, Winkler, Nebel, Sänger and Tiling. Then, from the film, "Spaceship I Departs," a rocket is seen taking-off from an inclined ramp and climbing away from the Earth.

There is considerable humour in the story of the powder rocket which follows, including all the flashy exhibitionism of Opel with his rocket-propelled cars, motor-cycles, speed-boats, rail-cars (the latter exploding in all directions) and a frustrated "rocket skater," whose first battery of rockets—attached to his back—merely fizzed effortlessly, and the second (presumably the more powerful two-shilling size!) pitched him forward on his face. Some measure of the absurdity of this so-called "research" can be gauged from the placing of a cat in one of Opel's rail-cars—to "test the effects of acceleration." The cat certainly accelerated, but unfortunately in several directions. The climax, however, was undoubtedly provided by Zucker. The introductory scenes were

* Reviewed in *B.I.S. Journal*, Vol. 7, No. 3, pp. 113–117. May, 1948.



Lake Greenwood Experiments, 1935.
The white-coated person nearest the camera is Willy Ley.



Dr. Winkler and Rocket HW.2.

of his not-too-successful postal-rocket experiments in the Isle of Wight; then, back in Germany, we witness the spectacle of his giant "controllable aerial torpedo" shouldered by members of the S.S. The missile is seen being placed on a light wheeled ramp pointed out to sea, whilst a crowd of military observers gather at a respectful distance. All is ready. The expectant hush that usually precedes a firing is apparent, even without a sound track; Zucker lights the fuses and up goes the "torpedo"—it executes a gentle loop, which a second later deposits a smouldering hulk on the beach. This apparently was Zucker's last official engagement, and we pass on to the more sober experimentation of Reinhold Tiling.

Preliminary sequences show Tiling and his assistant (Miss Angelika Buddenbohmer) firing small "aerial post" type rockets from a launcher having an adjustable tubular arm. The next stage covers the launching of Tiling's first "flying-rockets," having folded wings which snapped out at the peak altitude and caused the rocket to spiral gently earthward without damage. This led to the construction of larger winged rockets (of 4 metres (13 ft.) span), which on test at the Tempelhof Airfield near Berlin, reached altitudes of 762 metres (2,500 ft.) during 1931.

The performance of these rockets, bearing in mind that the fillings were conventional black-powder, was remarkably good, and the wing extending mechanism appeared to be perfectly reliable. The same type launcher in which the tail of the rocket was a sliding fit in a tubular arm, was used throughout. Another type rocket embodied hinged-tail fins which folded nearly horizontally to form supporting blades which caused the device to spin to the ground much like the "rotochute" now being developed in the United States for recovering instruments from high-altitude rockets.

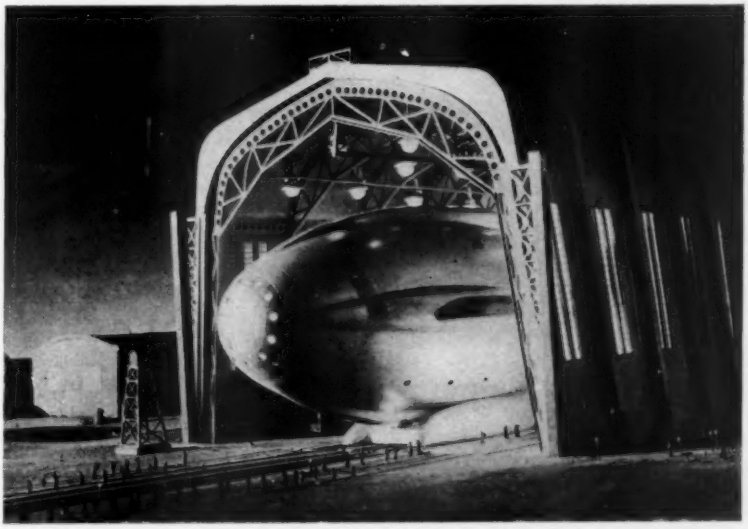
There is an interesting variety of shots of Tiling's workshop, powder-presses and launching racks, including some closing views of his work with military rockets fired from aircraft. Again, these indicate considerable success, the rockets having a remarkably flat trajectory and looking much like present-day R.P's.

Shortly after these pictures were taken, Tiling was killed, together with Miss Buddenbohmer and Friedrick Kuhr, his mechanic, when a heavy powder press they were using exploded, destroying the entire workshop; this was on October 11, 1933. It was said that Tiling's brother continued the work.

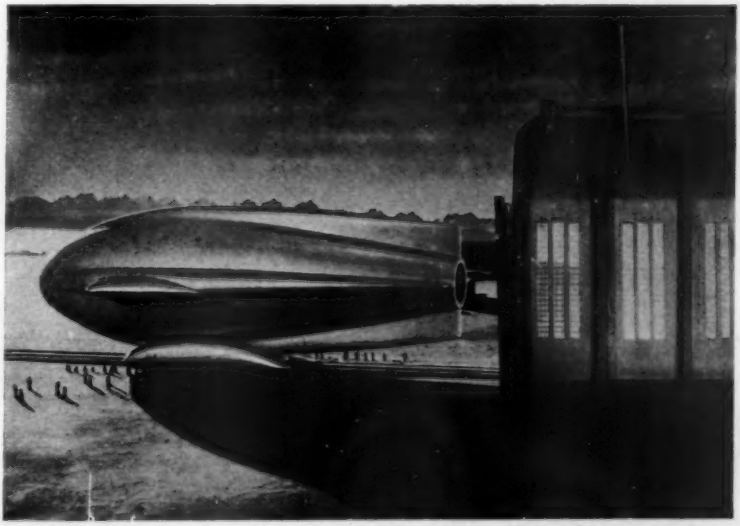
Particulars of early research by Goddard follow, comprising views of his test stand and equipment for solid-fuel shot motors and of his apparatus for proving recoil effect *in vacua*.

Some further shots of postal rockets by Schmiedl, Roberto, and others, brought the powder-rocket section to a close.

The story of bi-fuels begins with scenes from Fritz Lang's space-flight film made in 1929—"Frau im Mond." It will be recalled that Oberth collaborated on the technical side of this production and the rocket depicted is consequently a sensible representation, featuring vertical take-off and a booster which jettisons. The spaceship is seen in its hangar, being moved out on a railed track and finally set-up ready for launching. Its movement in space is also shown, including separation of the first stage.



Scenes from "Spaceship I Departs".



During the 1939–45 war this film was produced in Germany. As these pictures show, the models used were not very convincingly realistic, neither do they bear any resemblance to the appearance which the real "Spaceship I" may be expected to have.

There follow several interesting views of Goddard's early bi-fuel experimentation at Roswell, N.M., showing thrust recorders, observation trenches and tracking theodolites, and a "still" of his first gyro-stabilized rocket of 1932. Next, Valier's rocket car, powered by a single bi-fuel motor with a scarcely visible exhaust in marked contrast to the smoke-screens layed by Opel's vehicles using powder rockets. The car is, in fact, shown being driven around streets under perfect control.

Among the more interesting scenes of Winkler's research, following shots of his well-equipped workshops, are a number of the HW. 2 rockets intended for stratosphere flight. Winkler has the distinction of being the first European to produce a successful bi-fuel rocket. The rocket, which used liquid methane and liquid oxygen, rose to an altitude of about 600 metres (2,000 ft.) from a field near Dessau on March 14, 1931. Unfortunately, this test was not recorded. Several views are given, however, of the second rocket which embodied tail-drive, a nose parachute, and two spherical tanks for liquid oxygen and liquid methane; it measured 1·5 metres (5 ft.) and weighed approximately 50 kgs. (110 lb.). The launching preparations, fuelling, etc., are shown and finally, with German military officials in attendance, the HW. 2 is fired. If anyone deserved success, it must surely have been Winkler—the rocket appeared a most plausible design, in many ways resembling the later Walter bi-fuel A.T.O. units, and one gets the impression that the workmanship was most thorough. It was unfortunate, therefore, that the propellant valves allowed a trickle of gases to accumulate somewhere between the tanks and the outer casing, causing the rocket to explode a few feet above the launching rack.

The Raketenflugplatz, where the now almost legendary Mirak and Repulsor rockets were built and tested, is of particular interest. There can be little doubt that these programmes initiated the German ascendency in rocket engineering for, whether successes or failures, the results were always enlightening and the work continued in logical steps. However, if there is anyone still uncertain about *nose-drive*, then the flight of an early Repulsor should settle the question once and for all. It is doubtful if any rocket will ever perform so erratically again!

It is apparent, nevertheless, that nose-drive was not recognized as inherently bad for Magdeburg was the scene of the test of a large Repulsor-type rocket in June, 1933. This was the small-scale prototype of what was planned to be a man-carrying rocket 7·6 metres (25 ft.) in length, with a motor of 600 kgs. (1,300 lb.) thrust, to reach an altitude of 1 km. (3,300 ft.).

Surprisingly, this project was sponsored by the municipal government of the City of Magdeburg and though Nebel was in charge, it had no connection with the Raketenflugplatz or the VfR. After a series of static tests, a motor was finally approved which developed 200 kgs. (440 lb.) thrust. The rocket itself measured 4·6 metres (15 ft.) and comprised a scaled-down passenger cabin with fuel tanks in a single streamlined nacelle which had been placed on struts *beneath* the exhaust nozzle of the rocket motor in the nose. Quite a warm location for Magdeburg's "Buck Rogers"! Fortunately for him, the man-carrying version was never built, largely because of a series of mishaps to the prototype. The first flight test was arranged for the morning of June 9 and

it is this which features in the film. The rocket had a 9 metres (30-ft.) vertical launching rack, but when fired it only succeeded in rising up the rails before sliding down again, very slowly. After further tests, equally unsuccessful, the motor and tanks were finally converted into a four-stick Repulsor, 2·3 metres (7·5 ft.) long. It was fired from Lindwerder, an island in Tegeler Lake, near Berlin, rose up very fast to about 915 metres (3,000 ft.), suddenly somersaulted in the air, made a few more loops and finally power-dived into the water.

The film next covers Sänger's work, which dealt with the development of a long-range rocket aircraft and the design and construction of tube-jacketed rocket motors with continuous water cooling. Various examples of motors and associated equipment, pumps, etc., are shown, either as diagrams or actual test units. Of special interest are several water-cooled motors which were, in effect, very long expansion nozzles, tapering back directly into the injectors, without the customary combustion chamber. Mixing and combustion were theoretically supposed to take place in the throat and to give extremely high exhaust velocities.

There is also shown a letter dated February 3, 1934, signed by a Dr. Ing. Leitner and addressed to Sänger, officially turning down his suggestion for the development of military aircraft rocket units.

It appears, however, that Sänger's ideas, subsequent to the publication of his *Technique of Rocket Flight* in 1933, *were* becoming recognised, for in 1936 he was assigned a programme to develop a long-range rocket bomber. Workshops were established at Trauen and research, planned to cover a period of ten years, began in 1939; the centre became known as "The Research Institute for the Technique of Rocket Flight." These were Sänger's recommendations; to consider:—

(*a*) Air-forces and the form of airframes at Mach numbers between 3 and 30.

(*b*) Gas flow with simultaneous chemical conversion of the flowing medium.

(*c*) Air-forces in a large free path of the air molecules (extreme flight altitudes).

(*d*) Fuel research (in particular the burning of light metals, the dispersion and properties of liquid ozone).

(*e*) Research on materials (in particular, the materials for liquid oxygen pumps and high service combustion chambers).

(*f*) Construction of a high-pressure steam-driven turbo-pump for fuel and oxygen.

(*g*) Construction of ignition apparatus for the rocket motor.

(*h*) Development of a combustion chamber for extreme gas temperatures at 50 to 100 atm. gas pressure, with water-cooled walls and internal steam cooling. Objective: 100 tons thrust.

(*j*) Development of a supersonic catapult device for long-range rocket aircraft.

(*k*) Development of mathematical theory and calculation of trajectories for long-range rocket aircraft.

In 1942, it appears that this ambitious project came into conflict with the prosecution of the war; the work became increasingly hindered by the call-up of workers, including those in participating industrial concerns, and added to which the acute shortage of materials such as nickel, copper and chrome, eventually proved an overwhelming burden. The research was finally broken off in the summer of 1942.

A most completely outfitted test centre, Sänger's Institute, had facilities for testing one-ton thrust experimental gas-oil liquid-oxygen motors, using continuous water cooling through pipes tightly wound around the entire length of the combustion chamber. The combustion pressure was 100 atmospheres.

The work had progressed sufficiently by 1942 for construction to begin of the full-scale rocket motor of 100 tons thrust, and at least a mock-up cooling system was built, consisting as before of tightly-wrapped tubing. There was also developed a liquid oxygen pump with a supply capacity of 4 litres/sec., against 150 atmospheres.

The Institute boasted, in addition, the largest liquid oxygen storage tank in Germany with a capacity for 50,000 kg. (110,250 lb.).

Only the initial work on the long-range bomber project is covered by the film.

A summary of the ideas and achievements of foreign individuals and groups concludes the documentary—those of Ziolkovsky (1914); Bull and the American Rocket Society (1932); the Cleveland Rocket Society (1933–4); the Greenwood Lake experiments (1935); Loebell's model of a spaceship at the Paris Exhibition (1937); Shesta, Warren, Armengaud (1934) and Kessler (1935).

The closing scene is of the Earth slowly receding into the background of stars as "Spaceship I" departs. K. W. G.

NOTES AND NEWS

Conditions on Venus

The Astronomer Royal, speaking to a meeting of the Astronomical Society of South Africa at Johannesburg on October 28, 1949, had this to say on the subject of life on Venus:—

> "Venus, often spoken of as the twin planet of Earth, is hidden behind an atmospheric veil which has never been penetrated. Spectroscopic observations show that its atmosphere contains large amounts of carbon dioxide, but that oxygen and water vapour are entirely absent. The surface temperature is probably very high owing to the 'hothouse' effect of the carbon dioxide, and may even exceed that of boiling water. It would seem that the atmosphere is the seat of very violent storms which give rise to a great deal of dust from the arid surface, and that it is this dust which obscures the surface. The presence of large quantities of carbon dioxide and the absence of oxygen suggests very strongly that even vegetable life is absent on Venus, since plants absorb carbon dioxide and set oxygen free" (*Monthly Notes*, Vol. 8, No. 11, The Astronomical Society of South Africa, November, 1949).

Flames in the Absence of Gravity

A short note in the December, 1949, issue of *Ad Astra* (the journal of the Vereinigten Astronautischen Arbeitsgemeinschaften) contains an account of some interesting experiments by Dr. Ramsauer on the properties of flames under conditions of weightlessness. The experiments were carried out by filming a candle flame in a freely falling chamber.

It was found that the flame first became spherical, and then went out, since the normal process of convection had ceased to operate. Since the heated products of combustion could no longer rise and thus draw in fresh air, the flame suffocated itself.

Lighting a cigarette in a spaceship might therefore be somewhat difficult, since an ordinary match would be quickly extinguished—unless one kept it continually on the move. However, there would be no difficulty in making flames with chemicals containing their own oxygen supply, or with lamps using a forced air-draught.

These experiments suggest that it would be essential to have a very efficient air-circulation system in a spaceship, as otherwise a man who slept or remained for any length of time in the same place might be in real danger of suffocation!

Dr. Fritz Zwicky Honoured

On September 21, 1949, Dr. Fritz Zwicky, the noted Swiss physicist and astrophysicist, was awarded the U.S. Freedom Medal for outstanding services in obtaining particulars of German rocket development and for recommending the basic structure of the present rocket research programmes in the United States.

Members will also be interested to learn that Dr. Zwicky was recently elected a Fellow of the Society.

From the World's Press

Dr. Millikan recently (*Aero Digest*, September, 1949), reviewed the American organisation for "Guided Missile Development." He is present Chairman of the Committee on Guided Missiles of the Joint Research and Development Board, an official U.S. body which co-ordinates the programmes of the Air Force, Army and Navy, and of such organisations as the N.A.C.A. and the Bureau of Standards, as well as the many industrial firms and universities concerned. He said that, after reviewing the mass of captured German data, the American workers had now, for some time past, been producing original results of their own, and he revealed (as indicating the magnitude of the tasks involved) that during the development of V.2, some 1,600 test rockets were fired and 62,000 engineering modifications made, before any were launched against England.

* * * *

"Business Week" (New York, August 13, 1949) gave some interesting details of the growth of Reaction Motors, Inc., the firm which produced the motors for the Bell X-1, the Glenn Martin *Viking*, and many other rocket projects. In 1941, the U.S. Navy encouraged Lovell Lawrence (now company president of R.M.I.), John Shesta (director of research and engineering), and James Wyld (chief research engineer), to leave their good jobs and form their own company

to develop rocket motors. Until then, they had been "Sunday hobbyists" of the American Rocket Society. Their first engine gave 100 lb. thrust and earned them a U.S.N. contract for a range of motors from 100 to 1,000 lb. thrust, in February, 1942. In spite of these and other Government contracts, the new firm soon felt the lack of adequate working capital, but again the Navy "threw out a line" and induced Laurence S. Rockefeller, in 1947, to invest in the company, with the result that its present financial position, as well as its programme of work in hand, is stated to be very satisfactory.

The article mentions the Aerojet Engineering Corp., the Curtiss-Wright Corp., and the M. W. Kellogg Co., as being other firms engaged in rocket-motor development. (The first will be well-known to our readers, the second is the famous aircraft concern, and the last is the big engineering firm engaged, among other things, in boiler-making. They also built the Oak Ridge Diffusion Plant, for the separation of the U.235 isotope.)

* * * *

Following a recent article by Ken Gatland in *The Sunday Express*, a Mr. Gee, of Welsh Wales, wrote to that paper and pointed out that the B.I.S. had overlooked the fact that a rocket would give no thrust in a vacuum. The next week he was firmly dealt with by Arthur Clarke—but when will such people cease to imagine that they are likely to be able to uncover fundamental fallacies which have not been considered by all the hundreds of technicians who have, by now, studied the problem of space-flight? And we really did think this particular *canard* had died a natural death years ago!

* * * *

Reading about the *Rocket Club* of Birmingham, we wondered if we now had a competitor, and were further surprised to learn it was founded in 1897. However, it transpired that this was a social club, with benevolent objects and the three guiding principles of "charity, conviviality and comradeship." We wish all continued good fortune to the *Rocket Club* and (except that we believe, for practical reasons, that charity begins at home), we like to think that the B.I.S. shares their principles.

* * * *

The uses of hydrogen peroxide, other than as a rocket propellant, were indicated by Viscount Hall, First Lord of the Admiralty, at a Trafalgar Day luncheon of the Navy League. He revealed that the British Navy was at least as far advanced as other Powers in the development of submarines using H_2O_2 in special engines, to give underwater speeds as high as 25 knots.

It is interesting to reflect on the many problems which the submarine, also requiring an independent oxygen source, shares in common with the spaceship!

* * * *

Many Indian papers have recently carried accounts of amendments moved by Messrs. Kamath and Ahmed, in the Constituent Assembly at New Delhi, to include powers of interplanetary legislation in the new Indian Constitution. The motions were rejected and the general feeling seems to have been that the question of issuing interplanetary passports was irrelevant and premature at the present time. We can agree with this, of course, but we find ourselves more

in sympathy with Mr. Kamath's plea to the Assembly not to "shut their minds to the phenomenal advance of science," than with an editorial on the incident in *The Hindu*.

Written in would-be humorous vein, this commented that: "So far, rockets have shown a tendency to go only a few hundred miles." In very similar pontifications which appeared before the war, the only significant difference was the omission of the word "hundred." No doubt in another ten years, the word "thousand" will be substituted and, soon after that, the issue should resolve itself completely. Also, we suggest to *The Hindu* that they should not be too sure of their ungenerous statement that Mr. Forrestal was "not quite sound" when he announced official U.S. interest in the Earth-Satellite Vehicle Programme.

* * * *

The September, 1949, issue (Vol 2, No. 13) of the "Occasional Notes of the Royal Astronomical Society" consists of an historical paper on "Astronomy and Navigation," the conclusion of which is of considerable astronautical interest. The author, Dr. D. H. Sadler, is the Superintendent of the Nautical Almanac Office, and in a short section headed "The Future," he shows himself highly sympathetic to the ideas long discussed in this *Journal*. All B.I.S. members will certainly agree with his remark that "it is time that the astronomer began to take a serious interest in the new science of astronautics." Mentioning the Smith-Ross space-station, Dr. Sadler points out that such a satellite would be of immense value for navigational purposes as it would be ideally situated for applying the classical methods of astronomical position finding. At a distance of 10,000 kms., a 100-metre diameter object of good reflectivity would have a visual magnitude of about zero, and so would be one of the brightest objects in the night sky (Vega has magnitude 0·14). "The parallax of such a satellite would be 40 degrees or more, so it would provide a perfect means of determining position—apart from providing a new and powerful time and distance standard."

Dr. Sadler also devotes a paragraph to astronautics and remarks that "there has rapidly grown up a new science of the navigation of spaceships under the combined forces of gravitational attraction and rocket propulsion. . . . In the future cannot we visualise the navigator of a spaceship, an astronomer skilled in celestial mechanics beyond our present abilities and equipped with a "Space Almanac" and an electronic computing machine—for by no other means could he hope to keep control of the elaborate calculations—directing the propulsive units of his ship! How the computers of cometary or planetary orbits would envy his ability to change his velocity to avoid—or to encompass—a close approach to Jupiter!"

* * * * *

Writing in the *News Chronicle* for December 30, Ian Mackay noted that the American magazine *Time* had chosen Winston Churchill as the "Man of the Half Century"; he then proceeded to express the view that, in the long run, the man of science had a more secure place in history than the statesman, however eminent. "In the year 2450, if men are still allowed to think, they will be thinking more of Marconi, Einstein and Rutherford than of Churchill, Stalin and Roosevelt," thought Mackay, who also said: "By that time, unless

he has extinguished himself and returned to the primeval sludge, man may have conquered the cosmos or at least that part of it that holds allegiance to the sun."

Somewhat inexplicably, Ian Mackay ended his essay with what he called a "Terrifying Footnote," as follows: "As I wrote that last word, Ronald Walker waltzed in with the news that an aeroplane in California has just been flown 1,900 miles an hour, or three times faster than sound. That makes nonsense of everything in this column so far. And of everything else as well."

So far from making nonsense of his remarks, we should have said that it served as a striking illustration of their truth—unless Mackay was regretting his conservative estimate of 500 years for the conquest of the cosmos!

* * * * *

The report quoted above by Mackay referred to the rocket-propelled Bell X–1, which is certainly capable, at great heights, of a speed in the region of that which it is now claimed (by the *Los Angeles Times*) actually to have attained. U.S. Air Force circles, at the time of writing, refuse either to confirm or deny the claim, but admit that the X–1 has "substantially" exceeded sonic velocity on many occasions.

Donations to Library

The Council wishes to acknowledge with grateful thanks receipt of the following books, kindly donated by Mr. H. J. Marshal (Member).

New Methods of Testing Explosives (1905), by C. E. Bickel.
Treatise on Nitro-Explosives (1906), by P. Gerald Sanford.
Explosives: Their History, Manufacture, Properties and Tests. Three volumes (1917 to 1932), by A. Marshall.

Further similar acknowledgments are also due to Herr Heinz Gartmann for copies of:—

Weltraumflug Physikalische und Astronomische Grundlagen (1949), by Prof. Dr. Werner Schaub.
Raketen von Stern Zu Stern (1949), by Herr Gartmann;
and to Signor Giorgio Nebbia for a copy of *Elementi di Meccanica Ondulatoria* (Elementary Wave Mechanics): Italian translation by Professor Heitler.

Errata

The following amendments should be made to the Reference numbers in Mr. Ovenden's paper, "Astronomy and Astronautics," in the September, 1949, *Journal*:—

Page 185 line 33, for 18 read 13.
„ 188 „ 17 „ 13 „ 12.
„ 190 „ 41 „ 16 „ 17.

Personal

Mr. A. C. Clarke has been elected to the Council of the British Astronomical Association.

THE TRAJECTORY OF A POWERED ROCKET IN SPACE*

By George F. Forbes

SUMMARY.—This thesis presents a mathematical analysis applicable to a rocket in a central force space under the general condition of thrust tangent to the rocket path.

The general non-linear second-order differential equation is set up for the relations between the forces. The energy equation is developed and shown to be equivalent to the force equation.

The equations are studied and various expressions are developed. The time integral is set up and minimised for the real and for the imaginary part of the original (complex) vector equation. These minimal differential equations are combined with the given equations to determine the necessary conditions for a minimal curve.

Special cases are chosen for which the equations of motion are easily integrated. One of these cases is developed in some detail and a specific example worked out. It is shown that this special case (the logarithmic spiral) simplifies the mathematics of navigation. It is also shown that considerable saving of high thrust (low efficiency) motive power is possible when it can be replaced by continuous low thrust (high efficiency) power.

In general, a departure is made from the usual methods. Instead of considering momentum changes due to rocket exhaust mass, the rocket is treated as a particle being acted upon by an unspecified force while its mass is varying at an unspecified rate.

Notation

A' time rate of sweeping of area by $\overline{R}$.
a acceleration due to rocket motor thrust.
h $= tan\ \psi$ (see figure, in which the "F" symbols denote the forces acting on the rocket).
K (mass of attracting body) $\times$ (universal gravity constant).
R radius vector from attracting body to rocket.
t time.
γ convenience variable (see text).
θ polar co-ordinate angle.
ρ polar co-ordinate radius.
ψ angle between rocket motor force and radius vector from attracting body.
S' linear velocity.
Unless otherwise noted, all values in c.g.s. system.

The General Problem

The problem of the trajectory of a powered rocket in space reduces to a vector differential equation which is derived from the relation between the inertia of the rocket and the forces applied to it:

$$\overline{R}'' - \gamma\overline{R}' + \frac{K}{\rho^3}\overline{R} = 0 \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1{\cdot}13)$$

By expressing the vector $\overline{R}$ as the complex $\rho e^{i\theta}$, by breaking up the real

* This paper is an abridgement of a Masters' Thesis submitted to the Massachusetts Institute of Technology. The author has sent a copy of the full thesis to the Society, which will be glad to supply details on request.

Mr. Forbes' paper is of particular interest in view of the new result obtained that the co-tangential ellipse is not necessarily the most economical interplanetary orbit.

and imaginary parts, and by making a suitable change of variables, the following simultaneous equations are obtained:

$$\gamma = \frac{\rho''}{\rho'} - h^2\frac{\rho'}{\rho} + \frac{K}{\rho^2\rho'} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1{\cdot}1121)$$

$$\gamma = \frac{h'}{h} + \frac{\rho''}{\rho'} + \frac{\rho'}{\rho} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (2{\cdot}1212)$$

where

$$\gamma = \frac{a}{\rho'\sqrt{1+h^2}}$$

These second-order non-linear differential equations agree with equations derived by means of an analysis of the potential and kinetic energies of the rocket.

Even when the acceleration is specified constant, none of the standard methods of attacking differential equations seems to have much effect in the way of simplification. However, (2·1212) may be shown to lead to the expression:

$$\gamma = \frac{A''}{A'} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (2{\cdot}126)$$

which is an extension of Kepler's second law of planetary motion.

The acceleration is unspecified, however, so other assumptions may be made which might result in a solution in the form of a specified function for acceleration. This method proves to be practical in at least the cases $h' = 0$ and $\rho^3\theta'^2 = K$. The former is the condition for the logarithmic spiral and the latter is the condition that the velocity about the attracting body (Sun or planet) be inversely proportional to the square root of the distance. This is similar to Kepler's third law.

Undoubtedly, more relations can be found which would lead to solutions. These above cases are extensions of circular orbits and are thus much simpler than the elliptic orbit of the unpowered craft. They do not include cases of a gradual departure from the circular (satellite or planetary) orbit. It would be necessary to propel the craft into a specified path and velocity much as would be the case of elliptic orbits.

The Logarithmic Spiral

The mathematical calculations for this case are relatively simple. This spiral is a case for which the small but continuous acceleration of an electronic accelerator might replace considerable fuel mass.*

The solution to the original differential equations, obtained by replacing h by h_1, is in the form of a specification for the acceleration. That is, the equation:

$$a = \frac{K\cos\psi}{2\rho^2} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (12{\cdot}137)$$

* See, for example, Shepherd and Cleaver, "The Atomic Rocket—4" [*J.B.I.S.*, **8**, 59-70 (March, 1949)]—Ed.

Inasmuch as the cosine is always < 1, the rocket will not follow the logarithmic spiral for accelerations which exceed a certain maximum value. At the Earth's orbital radius, this maximum acceleration is $< \frac{1}{2}$ cm./sec.^{2}, i.e. is $< 0{\cdot}1$ per cent. of the acceleration due to gravity at the Earth's surface.

An illustrative problem is available. The mathematics will not be developed but equations will be stated as they are used. The numbering system is that used in the full thesis.

From (12·1372)

$$a_1 < K/2\rho_1^2 < 0{\cdot}03\% \text{ of Earth's gravity.}$$

That is, the maximum thrust needed to hold course is < 10 oz. per ton of ship mass.

From (12·1334)

$$t_2 - t_1 = \frac{2}{3}(\rho_2^{3/2} - \rho_1^{3/2})\sqrt{\frac{1+h^2}{K}}$$

h is found to be 4·90 and as $\tan \psi = h$, $\psi = 78{\cdot}5°$.

From (12·139) the initial acceleration is 0·0585 cm./sec.^{2}

$$a_1 = \frac{K \cos \psi}{2\rho_1^2} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (12{\cdot}139)$$

The final acceleration is 0·015 cm./sec.^{2}

From (12·1346) the total velocity change needed to go from the Earth orbit to the spiral and back to the Mars orbit is

$$\Delta S' = \sqrt{2K(1 - \sin \psi)}\left(\frac{1}{\rho_1^{1/2}} + \frac{1}{\rho_2^{1/2}}\right)$$

$$\Delta S' = 1{\cdot}08 \times 10^6 \text{ cm./sec.}$$

The corresponding figure for the elliptic orbit and a coasting rocket ship, based on the most efficient ellipse, is approximately $2{\cdot}5 \times 10^6$ cm./sec.

For an elliptic path, the total velocity change, including orbit matching and escape velocities for Mars and Earth, is $3{\cdot}96 \times 10^6$ cm./sec.

For a logarithmic spiral path, the total velocity change, including orbit matching and escape velocities, but not the continuous motor force, is $2{\cdot}61 \times 10^6$ cm./sec.

That is, the continuous force of not more than 2 oz. per ton of ship mass is equivalent to a saving of 35 per cent. in acceleration-time product. This would, of course, involve a saving of much more than that percentage of thermal type fuel.

A few equations relating to the logarithmic path might be of interest:

The equation of the path is

$$\frac{\rho}{\rho_1} = e^{\frac{\theta - \theta_1}{h_1}} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (12{\cdot}091)$$

The radial velocity is:

$$\rho' = \sqrt{\frac{K}{(1+h^2)\rho}} = \sqrt{\frac{K}{\rho}} \cos \psi \quad .. \quad .. \quad .. \quad .. \quad (12{\cdot}132)$$

The linear velocity is

$$S' = \sqrt{\frac{K}{\rho}} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (12{\cdot}1342)$$

which is equal to the linear velocity of a body on a circular orbit for the same radial distance from the Sun.

The radial distance from the Sun and the required acceleration are rather simply related:

$$\rho^2 a = \rho_1^2 a_1 \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (12{\cdot}138)$$

The Case $\rho^3\theta'^2 = K$

This case is physically that in which the angular velocity is always that of a circular orbit planet at the same radius. The acceleration is not limited as in the previous case. Also, it appears possible to change force direction at midpoint in order to decelerate.

The given assumption may be re-expressed by a change of variables

$$\rho\rho'^2 h^2 = K \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}091)$$

From which the original equations simplify to the expression:

$$\frac{h'}{h} + \frac{\rho'}{\rho} = 0 \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}10)$$

or

$$h\rho = h_1\rho_1 \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}101)$$

also

$$h_1\rho_1\left(\frac{1}{\rho_1} - \frac{1}{\rho}\right) = \theta - \theta_1 \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}1011)$$

[by substituting $h = \dot{\rho}\dot{\theta}/\rho$ in 42·101 and integrating].

and

$$\rho' = \frac{\sqrt{K\rho}}{\rho_1 h_1} = \Delta S \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}104)$$

That is, (42·104) is not only the radial velocity expression, but also the expression for the velocity change required of the on-course impulse.

The time relation is readily available

$$t - t_1 = \frac{2\rho_1 h_1}{\sqrt{K}}(\rho^{1/2} - \rho_1^{1/2}) \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}105)$$

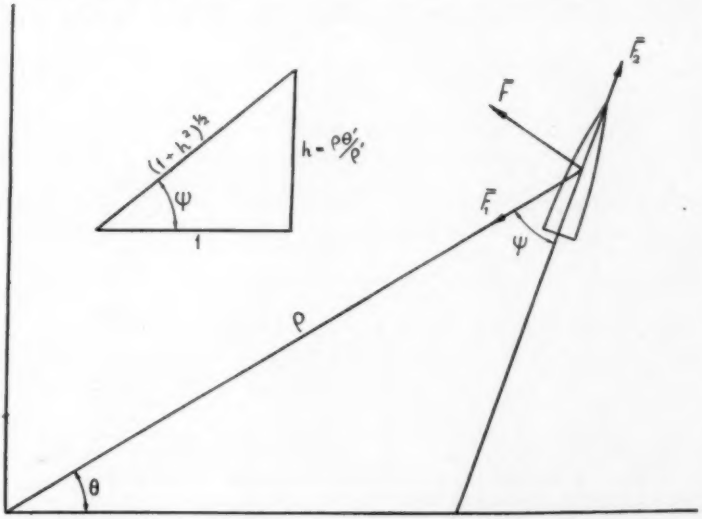
The acceleration is

$$a = \pm \frac{K \sec\psi}{2(\rho_1 h_1)^2} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}106)$$

The linear velocity is

$$S' = \sqrt{\frac{2K}{h_1\rho_1 \sin 2\psi}} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (42{\cdot}108)$$

In general, this latter case seems much more useful than the former. In both cases, and in general, K may be that for the Sun, for Earth, for the Moon, or for any other planet. It is only necessary to insert the appropriate numerical value. It may be noted also, throughout, that the mass is considered variable, but that all mention of mass and force cancel out to be replaced by that acceleration which is physically detectable because of the rocket thrust.



ABSTRACTS*

Edited by J. HUMPHRIES

Flight Beyond the Earth's Atmosphere

(F. H. Clauser. *S.A.E. Quart. Trans.*, Vol. II, No. 4, Oct., 1948, pp. 563-570, diagrams.)

This paper gives a short theoretical analysis of the "escape-problem" of a rocket, i.e. which rocket-design can achieve escape-velocity. Neglecting air-resistance and g.-variation the author considers the velocity at the end of burning for a single- and multi-stage rocket in vertical flight. In the formula of this final velocity, some parameters are introduced, among others a structural weight ratio and an initial acceleration load factor. Both these parameters are particularly discussed. It is shown that single-stage rockets using chemical propellants and having a low structural weight ratio (15 per cent.) fall considerably short of producing the desired velocity. For multi-stage rockets having the same exhaust-velocity and the same values of the aforementioned parameters

* Copies of many of the papers noted may be obtained from the Society's Loan Service on application to the editor at 97 Churchill Avenue, Southcourt, Aylesbury, Bucks.

the final velocity becomes a maximum if the stages are proportioned in a specified geometric ratio. The final calculations and the diagrams are showing that a rocket-vehicle consisting of four to six stages (the lowest value, if hydrogen and oxygen are used as propellants) can escape from the Earth.

The author concludes with the prediction that the development of a manned spaceship will take decades rather than years.

Principles de la Balistique Extérieure des Engins Autopropulsés Type V.2

(P. Blanc. *Mém. de l'Art Française*, tôme 23, No. 88, 1949, 2e fasc., pp. 311-385, diagrams.)

The extensive mathematical treatment and the calculations, which are given in this book-length article, relate to the real trajectories of the V.2 rocket. But the methods of calculation are also applicable to rockets with different characteristics, provided that these rockets have certain points in common with the V.2, such as constant mass-discharge, pre-set flight-path, no initial velocity, gyroscopic stabilisation, etc.

First the author considers the several elements (thrust, exhaust-velocity, mass decrease, air-resistance, etc.), which are of influence on the trajectories. The numerical value of these elements are given for the V.2. The drag-formula as used in aerodynamics is compared with the ballistic formula of Gàvre. Then the author gives the results of the calculation of the vertical trajectory with and without air-resistance.

In the next chapter some integration-methods, used to compute this trajectory and the curved trajectories, are explained and discussed. The described step-by-step ("small-arc") methods, which are needed because of the drag-term and the variation of g. and which have the time as independent variable, are compared with the classical method of Runge-Kutta on basis of their respective accuracy. Thereupon the author follows the same course with respect to curved trajectories: equation of motion, including also the force on the jet-vanes and the lift; numerical values of the forces; integration of the complete trajectory with different burning times. The paper concludes with some considerations on the regulation of the range as a function of the burning time and on the dispersion of this type of rocket.

Explosive Properties of Hydrazine

(F. E. Scott, J. J. Burns and B. Lewis. *U.S. Bur. Mines*, 1949, *Rept. Invest.*, No. 4460, 18 pp.)

In ten trials there was no indication of explosion when a 5 kg. weight was dropped from a height of one metre on to a one-drop (0·01 gm.) sample of either hydrazine or 85 per cent. hydrazine hydrate. In a Pyrex flash the ignition temperatures of hydrazine were 270° C. in air and 204° in oxygen; those of the hydrate 292° and 218° respectively. In an 18-8 stainless-steel cup an ignition was obtained at 152° and a failure at 171°. Experiments set the lower limit of inflammability of hydrazine at 4·67 per cent., by volume in air. The upper limit is 100 per cent. In an atmosphere of nitrogen, 38 per cent. or more of

hydrazine was required to form an explosive atmosphere, and in helium 37 per cent. The minimum pressure for spark ignition of hydrazine vapour was 12 mm. mercury in a tube 2·7 cm. diameter. In tests on the liquid-vapour systems, 1 ml. samples in an 89 ml. tube exploded only in the vapour phase at initial pressures up to, and including, 400 mm. mercury. At 600 mm. initial pressure, the apparatus, including the oil-bath, was blown apart.

Analysis of the First Rocket Ultra-violet Solar Spectra

(E. Durand, J. J. Oberly and R. Tousey. *Astrophys. Jnl.*, Jan., 1949, Vol. 109, pp. 1-16).

The spectrographic equipment installed in V.2 rockets is described, and an analysis made of solar spectra taken at heights of 35 and 55 km. The general intensity level of the continuous spectrum in the range, 2,950-2,600 Å., is shown to fall below that of a black body at 6,000° K.

The Atomisation of Liquid Fuels for Combustion

(J. R. Joyce. *J. Inst. Fuel*, Feb. 1949, Vol. 22, No. 124, pp. 150-6, illus., tab.)

Deals mainly with pressure-jet atomisers. Discusses their design and the common faults in design and manufacture. The combustion of liquid fuels, structure of atomised sprays and factors affecting atomisation efficiency are then dealt with.

Maintenance of Near Equilibrium During Isentropic Expansions Through a Nozzle

(S. S. Penner. *J. Am. Chem. Soc.*, March, 1949, Vol. 71, No. 3, pp. 788-91, refs.)

During the flow through a rocket nozzle many reactions occur so slowly, relative to the rate of cooling of the gases, that the chemical composition remains nearly unchanged. On the other hand, some reactions take place very rapidly and nearly complete chemical equilibrium may be reached throughout the nozzle. In general, the flow process as a whole is intermediate between these two extremes. If thermodynamic equilibrium is reached throughout the combustion chamber and nozzle then the thrust of the motor will reach a maximum. The nature of the flow process can be determined by a laborious numerical analysis. The present paper is devoted to a discussion of a simple criterion for near equilibrium during isentropic expansion.

Investigation of Some Parameters Affecting Over-All Rocket Performance

(C H. Harry. *J. A.R.S.*, June, 1949, No. 77, pp. 51-8, illus.)

This paper presents a simplified method of integrating the trajectory equations of a rocket-propelled vehicle, together with a study of the effects of mass ratio, thrust-to-gross-weight ratio, and rate of fuel consumption on the performance. The method gives better speed and precision than step-by-step processes. Serious errors may be noted at once during the calculations and sample methods may be used to carry out the integrations.

Sweat Cooling of Nozzle Surfaces Under High Thermal Stress

(F. Meyer-Hartwig. *Luftfahrtforschungsanstalt H. Göring, Braunschweig*, ZWB/FB/1740, Dec. 1, 1940. U.S. Air Force, Sept., 1948, Trans. No. F-TS-2067 (ATI No. 22204), 18 pp., illus.).

Calculation of the amount of coolant required by jet exhaust nozzles fabricated from a porous material and cooled by forcing a coolant through the material into the high-temperature interior of the nozzles. Includes a discussion of the properties of sintered metals for this application.

Nitromethane as a Monopropellant

(F. Zwicky and C. C. Ross. S.A.E. Special Pub., also condensed version as "Nitromethane Excels as Rocket Propellant," *S.A.E. Jnl.*, June, 1949, Vol. 57, No. 6, pp. 22-4, illus., tab.)

Nitromethane is a monopropellant with good handling characteristics and high performance. It is stable over a wide range of temperatures and pressures—decomposition temperature at atmospheric pressure of 500° F. compared with a boiling point of 220° F. Observations show that it is also extremely shock stable. It attacks commonly used stainless steels and aluminium alloys at rates less than 0·0001 in. per year and mild steel about 0·0005 in. per year. Most other common metals and alloys are attacked at low rates and some plastics resist completely. It has a theoretical specific impulse of 218 secs. at a combustion chamber pressure of 300 lb./in. and a corresponding density impulse of 248 secs.—chamber temperature 3,980° F.

On a Spectroscopic Method of Measuring the Velocity and Temperature of a Fast-moving High Temperature Gas (in French)

(I. Bredt. *Comptes Rend.*, June 20, 1949, Vol. 228, pp. 1927-9.)

Possibility of using broadening of spectral lines due to thermal agitation of gas to measure temperature of a moving high temperature source (e.g. a rocket jet) is discussed. Velocity of source could be found from observation of Doppler shift.

(From Sci. Abs., A., No. 6878, Dec., 1949.)

Supersonic Convective Heat-Transfer Correlation from Skin-Temperature Measurements on a V.2 Rocket in Flight

(W. W. Fischer and R. H. Norris. *Trans. A.S.M.E.*, July, 1949, Vol. 71, No. 5, pp. 457-69, illus., refs.)

Coefficients of convective heat transfer have been evaluated by analysis of the skin-temperature measurements made at several points on the nose of a V.2 (German A.4) rocket during flight in New Mexico. On one side, the surface of the nose was smooth, but on the other side, 4 in. from the nose-tip, a transverse ridge about $\frac{1}{8}$ in. high, was purposely provided as a turbulence promoter. The test results are compared in dimensionless form with various proposed correlations for both laminar and turbulent conditions of the boundary layer. The test results, thus correlated, seem to justify the following conclusions: (1) Boundary-layer transition seems to be more dependent, at supersonic speed,

on Mach number than on Reynold's number. (2) The theoretical heat-transfer correlation for a laminar layer is confirmed by the appropriate sets of test points to the estimated order of accuracy of the test. (3) For turbulent layer conditions, the subsonic correlation for a flat plate provides better agreement with the supersonic test results than does Eber's correlation, but there still remains a range of uncertainty as to the best choice of temperature for evaluation of the air properties.

A Survey of Injector Designs for Use in Liquid-Propellant Rocket Motors

(B. N. Abramson. Paper presented at Third National Convention of American Rocket Society, Dec. 2, 1948, 10 pp.)

A summary of the pertinent characteristics of ten types of injectors, built and tested by Bell Aircraft Corporation. It is concluded that the problem in the selection of an injector design is the compromise between high performance and ease of manufacture.

Rocket Chemistry at Inyokern

(F. G. Sawyer. *Chem. & Engng. News*, July 18, 1949, Vol. 27, No. 29, pp. 2067-9, illus.)

General description of Inyokern followed by details of chemical research. Important research lines are investigation of mechanisms and reaction kinetics defining the reactions of hydrazines with oxidants, fundamental research on nitrogen tetroxide and investigation of boron hydrides as water-oxidisable fuels. Due to drawbacks of nitrocellulose much effort is going into finding a substitute and an investigation is being made of the fundamental chemistry of the trinitrotoluene system. The development of solid propellants looms large in the programme.

The Applicability of Ceramics and Ceramals as Turbine-blade Materials for the Newer Aircraft Power Plants

(A. R. Bobrowsky. *Trans. A.S.M.E.*, Aug., 1949, Vol. 71, in Ital., No. 6, pp. 621–9, tabs., refs.)

Ceramic and ceramal materials have been investigated for use as turbine-blade materials for aircraft gas turbines. Tensile, flexure, thermal-shock, and oxidation data for these materials up to 2,400° F. are presented. These data are discussed with respect to applicability for turbine use. Results of turbine-blade operation at the N.A.C.A. Cleveland laboratory are given. (*Note.*—The data given are of great use in assessing the possibilities of using these materials in rocket combustion chambers.—J. H.).

Other Papers Noted

Commercial Possibilities of Guided Missiles and Pilotless Aircraft. A. P. Gertz, *U.S. Air Services*, Oct., 1948, Vol. 33, No. 11, pp. 9, 11, 24.

Rocket Propulsion. A. V. Cleaver. *Forecast*, Dec., 1948, Vol. 10, pp. 511–9, 524.

On a Necessary Condition for the Transformation into Satellites of the Planet of Bodies Projected from a Planet. (In Roumanian.) C. Iacob, *Gaz. Mat.*, Bukarest, 1949, Vol. 54, pp. 192-201.

Fliegen durch den Weltenraum. H. H. Kölle. *Die Weltluftfahrt,* Jan. 1949, Vol. I, No. 1-2, pp. 24-5, illus. Chronological résumé of the history of rocket propulsion.

Major Developments in the Field of Rocket Engines. K. F. Mundt. *Western Flying,* Jan., 1949, Vol. 29, No. 1, pp. 11, 15, 16.

Will Missiles Replace Fighters? R. G. Naugle. *Flying,* Jan. 1949, Vol. 44, No. 1, pp. 20, 21, 72, 73, illus.

What is Happening in the Field of Rockets, Jet Propulsion, and Supersonic Flight. J. T. McMarney, U.S. Central Air Documents Off. (Navy-Air Force), *Tech. Data Digest,* Jan. 15, 1949, Vol. 14, No. 2, pp. 15-21. Future American development of the guided missile and its tactical facilities.

Rocket Power. Naval Aviation News, Feb., 1949, No. 22, pp. 1-7, illus. History, wartime development and propellant problems.

Guided Missiles Span New Horizons. S. B. Beaudry. *Ryan Reporter,* Feb., 1949, Vol. I, No. 2, pp. 2, 3, 14-16, illus. Brief résumé of the power plants, control systems and the types of missiles that have been developed.

Navy Pioneering in Guided Missiles. D. S. Fahrney. *The Pegasus,* Feb., 1949, Vol. 13, No. 2, pp. 1-5, 16, illus.

Desert Rocket Haven (Naval Ordnance Test Station. Inyokern, Calif.), Naval Aviation News, March, 1949, No. 24, pp. 11–13, illus.

U.S.A.F. Reveals Development of Two Guided Missiles (Consolidated Vultee 744 and the NATIV). U.S. Central Air Documents Off. (Navy-Air-Force), *Tech. Data Digest,* March 1, 1949, Vol. 14, No. 5, pp. 12, 13.

Leader in Guided Missile Research (The Glenn L. Martin Co.). W. B. Bergen. *Martin Star,* March, 1949, pp. 5, 15, illus.

Ballistic Rockets. W. Bollay. *North American Skyline.* May, 1949, Vol. 7, No. 1, pp. 12-15, illus.

Can We Build a Station in Space? R. P. Haviland. *Flying,* May, 1949, Vol. 44, No. 5, pp. 19-21, 68-70, illus.

Missiles go into Production. Business Week, June 25, 1949, pp. 36-7, illus.

Needle-Nose NATIV. Skyways, June, 1949, Vol. 8, No. 6, p. 17, illus.

Rhine Messenger. Technology Rev., June, 1949, Vol. 51, pp. 498-9.

Three and One-half Times the Speed of Sound; Martin Designs and Fabricates the Vehicle (Viking) which Uses a Rocket Power Plant, now Being Tested by the Navy. U.S. Air Services, June, 1949, Vol. 34, No. 6, p. 8.

Design and Experimentation on a Basic Rocket Engine. A. Bernstein, F. D. Linzer, N. Y. Rothmayer and A. Sherman, *J.A.R.S.,* June, 1949, No. 77, pp. 79-89, illus., tabs. Design details and test runs on a small gasoline/oxygen motor.

A Charging Valve for Compressed-Air Rocket Models. P. G. Couperus, *J.A.R.S.,* June, 1949, No. 77, pp. 90-3, illus. On the use of compressed air as the source of energy to propel small rocket-type research missiles.

Hydraulic Analog of Flow Through Supersonic Nozzles. H. V. Schenk, *J.A.R.S.*, June, 1949, No. 77, pp. 75-8, illus., refs. Consideration of some of the similarities between the flow of water in diverging-converging open channels and the flow of gases through supersonic nozzles.

3,000-*Mile Missile Test Range to Banana River Gets Started. The Martin Star*, July, 1949, Vol. 8, No. 7, pp. 2, 18, illus.

REVIEWS

Weltraumfahrt—Utopie?

(Various authors: *Verlagsbuchhandlung Natur und Technik*, Wien, 1948. 52. pp.)

This little book consists of ten articles reprinted from *Natur und Technik*, the titles and authors being as follows:—"Foundations of Space-travel" (Kurt Pervesler); "The Rocket Through Interplanetary Space" (Robert Klumak); "The Shot to the Moon" (Karl Wanka); "The Outer Station, Spring-board into Space" (Guido von Pirquet); "With Atomic Power into Space" (Ferdinand Cap); "Rocketposts—Postal Rockets" (Friedrich Schmiedl); "To the Limit of the Atmosphere" (Erich Dolezal); "Rocket Propellants" (Manfred von Stein); "The V.2 Rocket in the Service of Upper Atmosphere Research" (Viktor Oberguggenberger); "Manned Flight in Space" (Theodor Wense).

The first two papers give a thorough survey of the problem from first principles. Karl Wanka's short (3 pp.) article gives some interesting information on the path of a projectile from Earth to Moon, but perhaps the most important paper is von Pirquet's, which discusses the advantages of orbital refuelling with particular reference to the circumnavigation of the Moon. Quantitative results are worked out for several actual cases and typical trajectories are shown. The article on the medical aspects of space-flight is also very thorough and contains some useful information on the physiological effects of high accelerations and low pressures. A. C. C.

Rockets and Jets

(Compiled by R. Barnard Way and Noel D. Green, A.M.I.Mech.E. Wells Gardner, Darton & Co., Ltd., Redhill, Surrey, 176 pp., illus. 5s.)

This is a well-produced but non-technical book, intended as an introduction to the subject of rocket and jet propulsion for young readers. The authors devote the first two chapters to a brief survey of the history of rocketry, and a basic explanation of the manner in which a rocket functions. They then deal with rocket fuels and motors, detailing the various forms of propellant feed, and illustrating the applications of rocket power to aircraft and short- and long-range guided missiles, by sketches and descriptions of Me.163, Natter, X.4, He.293, Wasserfall and A.4.

In the fifth chapter the authors describe the A.9/A.10 projects, and then in four pages attempt to cover the basic problem of escape from the Earth! A scheme is outlined for a four-step circumlunar rocket, allowing for the return to Earth of the 2-ton payload. The initial mass is given as 40,260 tons—the

effective mass ratio from the figures given is 256. Unfortunately, however, no mention has been made as to the exhaust velocity assumed in calculating this project. The authors have failed to explain the effect which variations in the mass ratio or exhaust velocity have on the final rocket velocity. They have also omitted to state why the step rocket principle has to be used in projects requiring a very high characteristic velocity. A diagram is given here of the trajectory described by a rocket with a velocity at "all burnt" of 8 km./sec. (5 miles per sec.). The trajectory is shown extending to the null point between Earth and Moon. In actual fact, the difference between the velocity required to reach the null point, and escape velocity amounts to some 100 metres/sec.!

The second half of the book deals with the various forms of jet propulsion. The two simplest forms—the resonance duct and athodyd, are dealt with first, and, in the remaining five chapters, the basic principles involved in the design of the modern jet turbine are set down. The majority of this section of the book deals with the British developments in this sphere, and is well illustrated, with diagrams showing the functioning of the main components of both the axial and centrifugal flow type of jet turbine. The working of the prop jet has also been explained, being illustrated by diagrams of the Armstrong Siddeley "Mamba" and Bristol "Theseus" as working examples.

In general, the book is well produced and is well illustrated with black and white line drawings and diagrams, but its value is much reduced owing to the very large number of errors which appear in the text. A. M. K.

Our Sun

(By Donald H. Menzel. The Harvard Books on Astronomy. The Blakiston Co., New York; J. & A. Churchill, London. Pp. viii + 326, with 178 diagrams and photographs. 1949.)

This, the latest addition to the Harvard Books on Astronomy, has been long awaited. Its conception came as early as 1938, and the protracted period of gestation was due in the most part to a strange manifestation of war-time bureaucratic mentality which gave to solar studies, no matter how familiar to the opposing powers, military classification.

In style and format it follows closely its well-known predecessors. Written by an important contributor to and acknowledged expert on both the practical and theoretical approaches to solar physics, the general account which it gives is both authoritative and reasonably up-to-date. Prof. Menzel has attempted to cover a wide field, from an introductory dissertation on ancient sun-lore and mythology through the history of solar research, to a detailed description of the complex local phenomena observed on the sun and in its atmosphere. Two primarily non-astronomical chapters deal with light and its properties, and atoms and molecules; these differ in no material way from the similar chapters appearing in nearly all the other Harvard Books. The chapter on the internal structure of the sun contains much that is not generally classed astronomical, being largely a popular account of atomic physics. A final

chapter—engagingly titled "The Sun—And You!" deals with solar-terrestrial relationships, established and hypothetical, and the possible domestic (and in particular, culinary) harnessing of solar energy. As with its companions, the volume is profusely bedecked with excellent illustrations, in this case of solar prominences, sunspots, corona, etc., for which alone the book would be worthwhile. Less deserving of merit are the portraits of astronomers that suddenly spring from the text at unexpected and usually irrelevant places, and which bear no temporal relationship to each other; a white-haired Einstein of the newest relativity sits unhappily in juxtaposition to a youthful Eddington whom one could well believe to be about to sally forth with the Greenwich Observatory hockey team!

Our Sun has been long awaited—but "to travel hopefully is better than to arrive," and it is difficult not to be a little disappointed with Prof. Menzel's account. In common with many semi-popular transatlantic scientific texts, the Harvard Books are a product of an educational system differing markedly from our own, and tend in their strange environment to fall between two stools. It is difficult to envisage a general reader who would wish for detailed accounts of the behaviour and classification of prominences but who nevertheless requires a description of a spectroscope in the simplest of terms; or one who will appreciate both a description of how to make a telescope from a lens and a cardboard tube, and, 30 pages later, photographs of mechanical vibrations illustrating the electron vibrations of a hydrogen atom. Yet for the serious student it remains, with all its detailed descriptions, little more than superficial, for it rarely gets to grips with the problems of solar physics.

Within these limitations, it fills a serious gap in astronomical literature, and may confidently be recommended to any who seek a straightforward, simple yet accurate and topical account of our knowledge of "Our Sun."

M. W. O.

CORRESPONDENCE

Prof. Hermann Oberth—a Reply to Otto Hester

(We have received the following letter from Prof. Dr. Wernher von Braun, who is anxious that his attitude toward Prof. Oberth should not be misunderstood by readers of Otto Hester's letter, published on pp. 210–212 *of the September,* 1949, B.I.S. JOURNAL.)

SIR,—As a pupil of Prof. Hermann Oberth who has always felt the greatest admiration for this outstanding pioneer of rocketry and space travel, I feel obliged to correct a few statements by Mr. Otto Hester concerning the Peenemünde Command's attitude towards Prof. Oberth. Since I was the Technical Director of the Peenemünde Rocket Centre during the war, Mr. Hester's contribution might arouse the suspicion that I was trying to keep Prof. Oberth out of the more important phases of the Peenemünde development for the sake of my own credit. So let us get the record straight:—

1. In 1938, Prof. Oberth was called to the Technische Hochschule, Vienna, under a *Luftwaffe* contract, while the development of the V.2 and

its predecessors was conducted at Peenemünde under *Army* auspices. The Luftwaffe did not consult Peenemünde prior to this step, nor were even the whereabouts of Prof. Oberth known to me at the time. In 1940 or 1941, the Luftwaffe invited me to visit Prof. Oberth at his installation near Vienna. It became plain that the Luftwaffe—

(*a*) had hired Oberth's services with the intention of creating an inter-service competition to the fast-growing Army domination of the liquid rocket field;

(*b*) had given him utterly inadequate means to conduct his experimental work (one miserable test-pit, one mechanic);

(*c*) was disappointed that he had not achieved revolutionary results with the help of these primitive facilities.

2. Shortly before my visit to Vienna, a general Service policy decision had been made in Berlin, to the effect that "buzz-bomb" type guided missiles (V.1) came under the control of the Luftwaffe, while rocket-type ground-to-ground missiles (V.2) came under the Army. Hence the Luftwaffe was now discontinuing its competitive "experiment" and offered Prof. Oberth's help to the Army. I was extremely pleased at the prospect of winning him into our camp.

3. However, there was a catch in this whole business. At that time, Prof. Oberth still held Roumanian citizenship and the Intelligence people were not willing to admit him to the then "top secret" Peenemünde plant. All we could do was to assign Prof. Oberth temporarily to a sub-project at the Technische Hochschule, Dresden, where improvements for the V.2 turbo-pump were under way under a Peenemünde contract. At the same time, we started an all-out effort to ram Prof. Oberth's application for German citizenship through the slow-grinding bureaucracy of the German Foreign Office.

Prof. Oberth received his German citizenship at a time when the development work on the V.2 rocket was practically completed and mass production was just about getting started. We invited him to come permanently to Peenemünde, which he accepted without delay.

4. I had previously worked under Prof. Oberth's direction only during the summer of 1930, until he left for Roumania in the autumn of the same year. To anyone who ever dealt with technical development, it will be intelligible that during 12 years of separation and constant labouring in the "mundane realm of practical engineering development" on my part, a certain deviation from the track (as conceived by the pioneer and master) was unavoidable. It was small wonder, therefore, that Prof. Oberth, after his initial amazement about what he saw accomplished at Peenemünde, told me quite frankly and cordially, that he did not agree with all our solutions and that he would have done many things differently. I have never doubted that many problems encountered in the development of a liquid-fuel rocket could have been solved in a different and even better manner than used in the V.2. Therefore, Prof. Oberth's constructive criticism never affected our perfect personal relationship. With the V.2 already in the stage of tooling for

quantity production, and in view of the wartime pressure toward completion of the development, Prof. Oberth fully realised that for essential alterations and incorporations of novel proposals, it was too late.

5. Since the V.2 was therefore a closed case, as far as major alterations were concerned, Prof. Oberth plunged into various project-planning jobs. Among other things, he wrote an excellent paper on the optimum weight division in multi-stage rockets. At his own desire, he joined the Peenemünde wind tunnel for a while to familiarise himself with modern supersonic wind tunnel techniques. With the fullest approval of my military superior, General Dornberger, I gave Prof. Oberth the widest latitude in choosing his own field of activity, which was his due in the face of his outstanding pioneering in the rocket field.

6. Finally, Prof. Oberth submitted a proposal for a solid-fuel anti-aircraft missile. By that time, we already held a contract for the development of what later became known as the "Wasserfall" A.A. missile, a liquid-fuel job. Since Peenemünde did not deal with solid-fuel rockets, Prof. Oberth's proposal was conveyed to the WASAG plant, Reinsdorf, the most efficient German powder-rocket factory. He started development of his solid-fuel A.A. rocket at this plant, but the war's end interrupted his efforts, which were doubtless extremely promising.

7. There is no doubt that Prof. Oberth's connections with the German Armed Forces contained many disappointments for him. During all the years when the groundwork for the later V.2 was laid, he lived in the seclusion of his Roumanian home. Later, his active participation in the development was hampered by his foreign citizenship. And finally, when he came to Peenemünde at last and the curtain went up, he saw his own baby grown up and educated along lines he could not quite agree with. He might even have felt a stranger among the new generation of rocketeers his own imagination had brought into being, many of the youngsters not even knowing what they owed him. . . .

But to me and most of the older rocket enthusiasts (I'm now 37 and I've come a long way since I started out under Oberth at 18), Prof. Hermann Oberth will always be the father who inspired our thought, even though we may have spoiled his brainchild a little bit.

FORT BLISS, TEXAS, U.S.A. WERNHER VON BRAUN.

November 20, 1949.

Symposium on Medical Problems

Dr. R. Graham White, of Rusapi, Southern Rhodesia, in the course of a letter to the Secretary, raises a point regarding the mechanism of the inner ear. He writes:—

"I personally think that the removal of gravitational forces would cause the particles in the semicircular canals to undergo Brownian movement, with the result that Ménière's syndrome—noises in the ears, vertigo, vomiting and nausea, with nystagmus, i.e. jerking of the eyes, would occur. Since the most effective treatment is division of the 8th (auditory) nerve, and it would have to

be bilateral, space pilots may be asked for quite a lot! Permanent and complete deafness of both sides is no joke."

The answer, I think, is that Brownian movement is going on all the time, independently of the presence or absence of gravity, and does not normally lead to untoward symptoms. Dr. Löwenstein's experiments show that the sense organ at the end of each canal is partially distended, and therefore sending out nerve impulses, even when the fluid is at rest. The distension is due to the mere presence of the fluid within, not to its weight.

I would like to add a comment on Dr. E. T. O. Slater's paper, at the end of which he stated that explorers in virgin country, where no man has been before, do not find the animals hostile; he therefore anticipates that a friendly attitude, or at least not a hostile one, would greet human space travellers on encountering intelligent life on another planet.

This optimism does not seem to me justified. It is only the vertebrate animals who are capable of a friendly attitude, and they form a minority of the fauna.

The great group of arthropods, who have external skeletons, far exceeds in number of species all the other animals combined, including the chordata, to which the vertebrates belong. H. G. Wells has written of this group, or phylum, that it "includes all the insects which creep and buzz about us, bite and pester us, sting and poison us, the spiders that shroud our rooms and cellars, the lice that infest us, and earwigs that creep and run from every stone we turn. It is a strange, competitive world side by side with the chordate phylum, unsympathetic, alien, and for the most part hostile and malignant to it."

The vertebrates are the only animals to display any sort of emotions with which we can make contact. It may be that, just as horned animals tend to evolve larger horns, so vertebrates tend to develop the higher emotions as an inevitable result of evolutionary progress, though the tendency for vertebrate creatures to evolve from lower forms of life seems by no means inevitable.

But from our present knowledge of evolutionary processes, we can have no certainty of finding the emotional and mental make-up of terrestial vertebrate animals displayed anywhere else in the Universe. A. E. SLATER.

WHIPSNADE, BEDS.

SIR,

Protection Against Meteors

I should like to make an observation in connection with the article by A. C. Clarke, entitled "Meteors as a Danger to Space Flight," which appeared in the July, 1949, issue of this *Journal*.

The article mentions Whipple's suggestion that a secondary shell enclosing the cabin and spaced from it by about one inch would be an effective "meteor bumper."

This is not exactly a new idea. As a matter of fact, the cabin of the pre-war "B.I.S. spaceship" was visualized as being double-walled in this manner, with the dual object of providing satisfactory thermal insulation and of absorbing the impact energy of meteors. H. E. ROSS.

HIGH WYCOMBE, BUCKS.

A Disclaimer

Mr. R. L. Farnsworth (President of the United States Rocket Society, Inc.) has written to us disclaiming responsibility for the statement that the Canadian Rocket Society "were just a bunch of amateurs etc."

This was attributed to him by United Press and Associated Press reports appearing in the *Evening Standard*, dated July 19, 1949, and quoted in the September, 1949, *B.I.S. Journal*.

RECENT AND FORTHCOMING MEETINGS

December 5, 1949 (Monday). "Rocket Propulsion and Interplanetary Flight" by A. V. Cleaver, to the Bristol Branch of the R.Ae.S.

January 17, 1950 (Tuesday). "Interplanetary Travel," by A. C. Clarke, to the Edmonton Rotary Club, Regal Restaurant, Silver Street, N.18.

February 8, 1950 (Wednesday). "Recent Advances Towards Interplanetary Travel," by G. V. E. Thompson, to Ilford District Branch, Association of Scientific Workers, Seven King's Library, Seven Kings, Ilford, Essex, 7 p.m.

February 18, 1950 (Saturday). A meeting of Fellows of the Society to discuss Technical Policy at St. Martin's School of Art, Charing Cross Road, W.C.2, 3 p.m.

February 20, 1950 (Monday). "Rockets and Interplanetary Travel," by J. Humphries, to Leighton Park School Science Society, Reading, Berks., 6.30 p.m.

February 21, 1950 (Tuesday). "Into Space," by E. Burgess, to the Manchester General Branch, Association of Scientific Workers, in the Czech Room, International Club, 64, George Street, Manchester, 1, Lancs., 7.30 p.m.

February 22, 1950 (Wednesday). "Interplanetary Travel; Its Impact on Humanity," by A. C. Clarke, to The Heretics, Oxford.

February 27, 1950 (Monday). "Interplanetary Travel," by G. V. E. Thompson, to Forest Hill and Sydenham Branch, International Friendship League, Friends' Meeting House, Venner Road, Sydenham, 8 p.m.

March 3, 1950 (Friday). "Rocket Propulsion and Interplanetary Flight," by A. V. Cleaver, to the Physical and Chemical Society of Durham University, in the Science Laboratories, South Road, Durham City, 5.15 p.m.

March 4, 1950 (Saturday). "Testing of Rocket Motors," by Dipl. Ing. H. F. Zumpe, to the Society at Caxton Hall, S.W.1, 6 p.m.

March 11, 1950 (Saturday). "Short Evening Papers," to the N.W.D.C. of the Society at Adult Education Institute, Lower Mosley Street, Manchester, 2, Lancs., 6.30 p.m.

April 1, 1950 (Saturday). "Space Travel, Fact and Fiction," by A. C. Clarke, to the Society at Caxton Hall, S.W.1, 6 p.m.

April 15, 1950 (Saturday). Film Show to the N.W.D.C. of the Society, showing "Operation Backfire," "Faster than Sound," "Atomic Physics (Part V)," etc. At Adult Education Institute, Lower Mosley Street, Manchester, 2, Lancs.

May 6, 1950 (Saturday). A repeat Film Show to members of the Society at the Science Museum Lecture Theatre, showing "Operation Backfire," "Faster than Sound," etc. Admission by ticket only. Early application should be made to the Secretary as accommodation is limited.

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